FEBRUARY 1951

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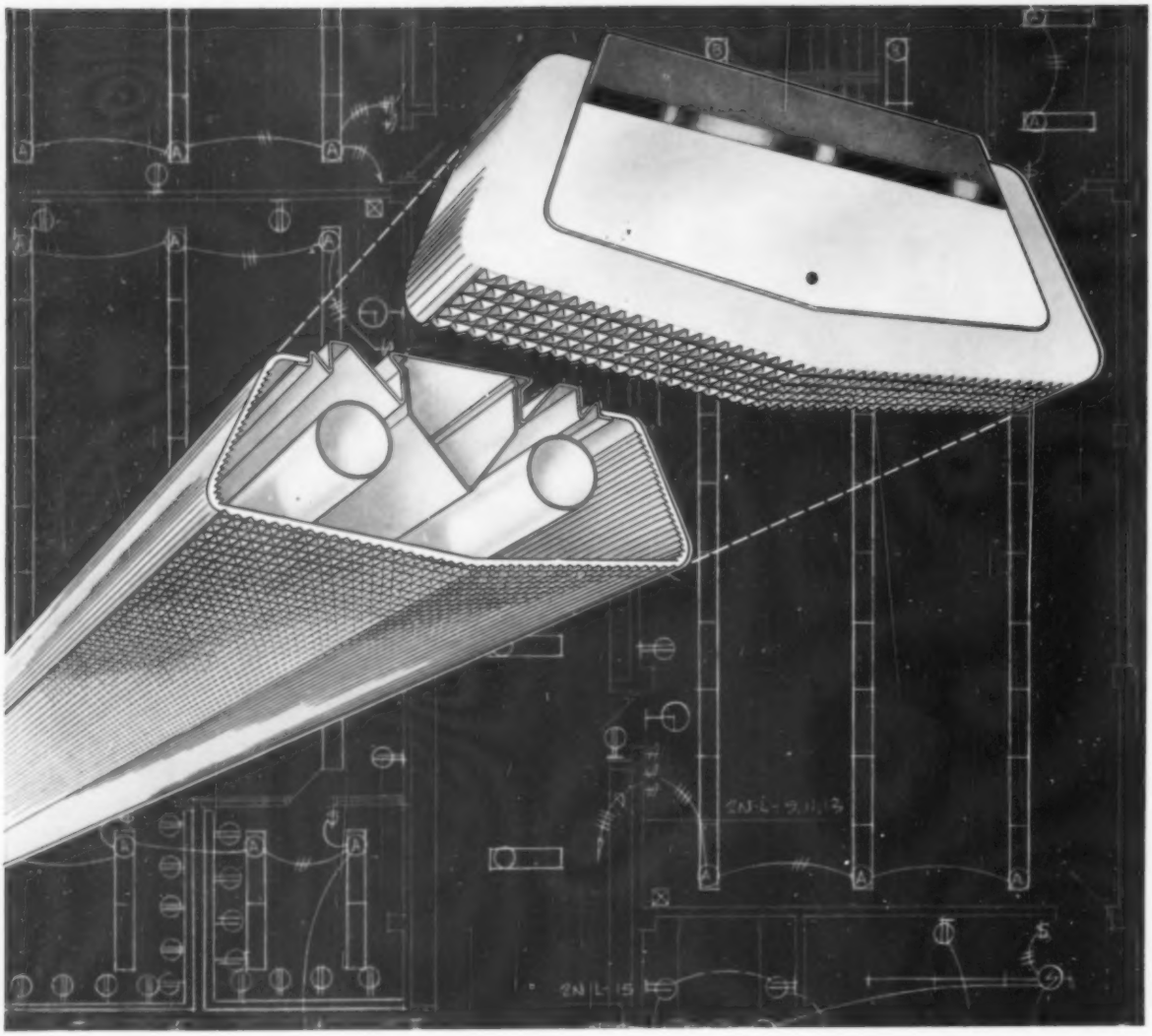
ILLUMINATING ENGINEERING

Journal of the
ILLUMINATING ENGINEERING SOCIETY



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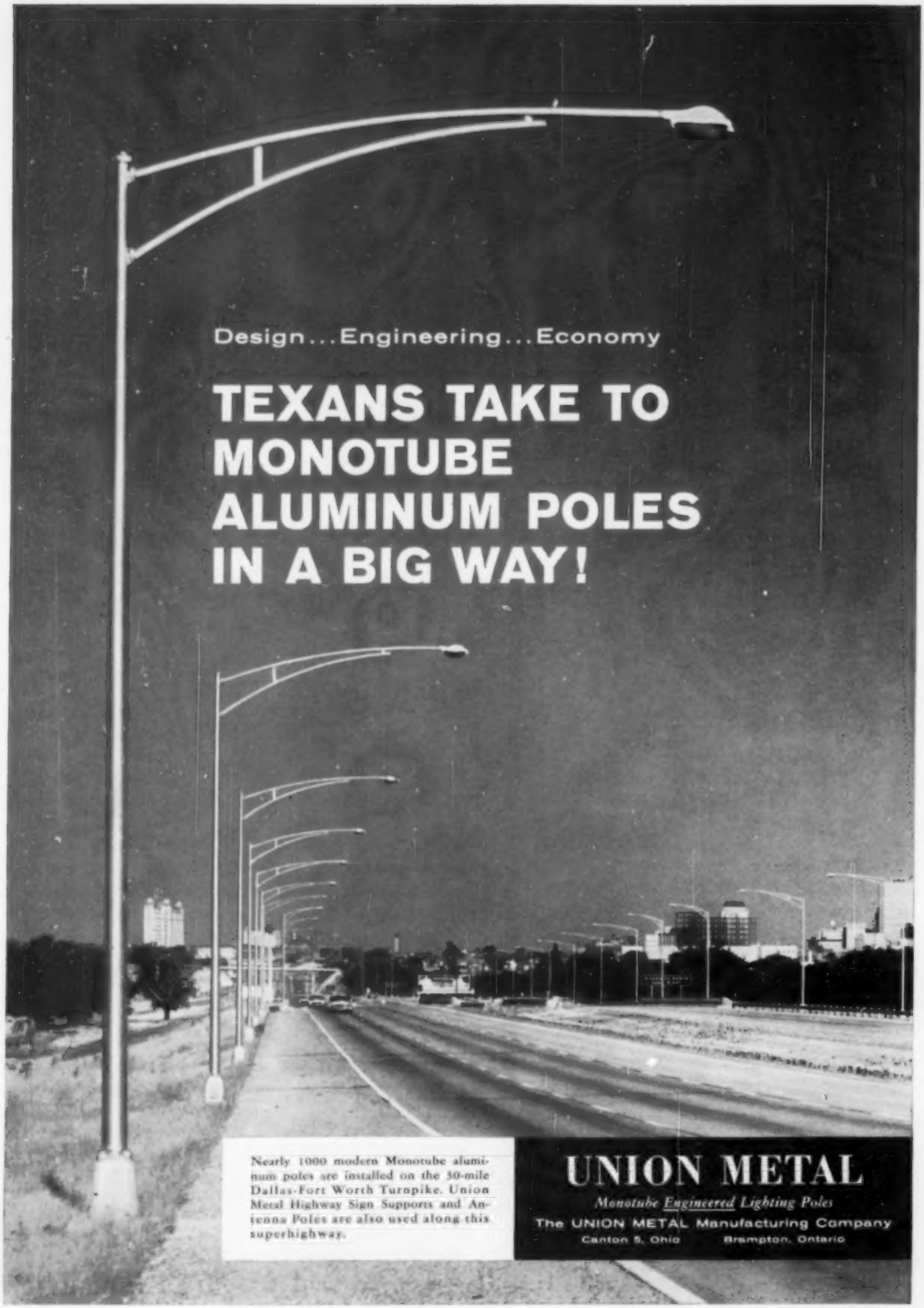
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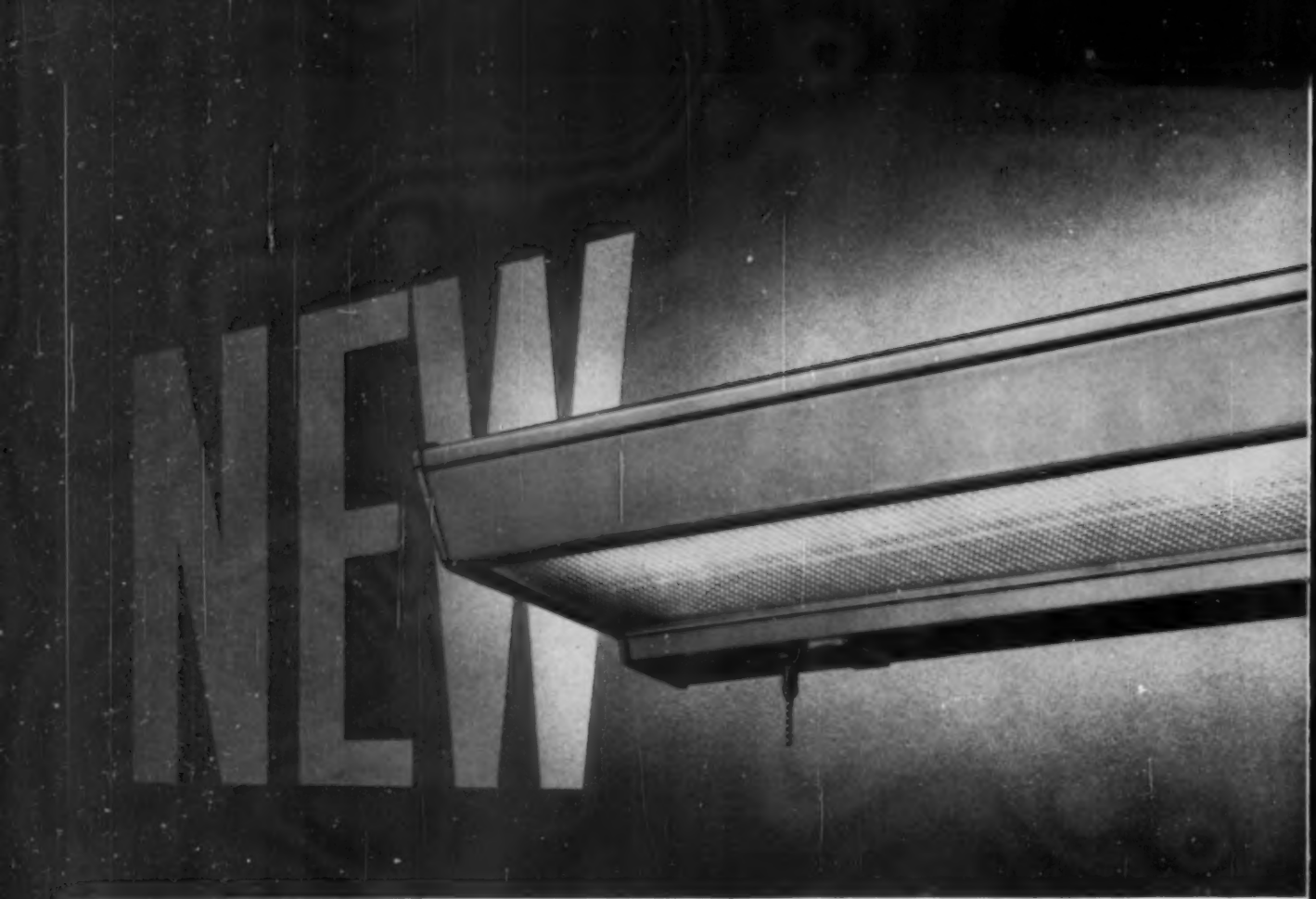

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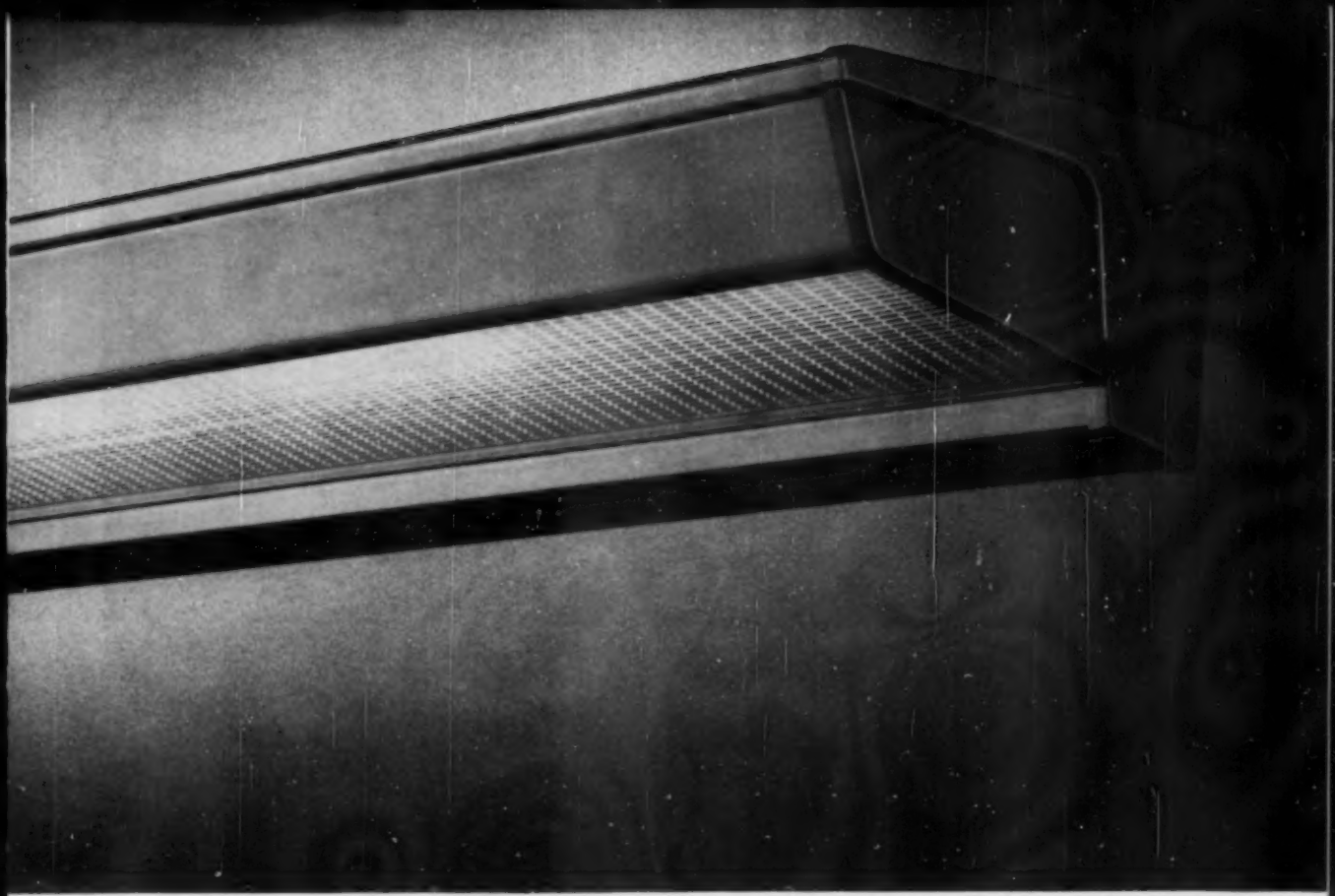

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ARCHITECT: W. H. Jones & Son, Melrose, Massachusetts

ELECTRICAL ENGINEER: Martin E. Keane Associates, Boston, Massachusetts

AREA SHOWN: Tellers' Area and Public Area

CEILING HEIGHT: 12' — 0" in Tellers' Area; 18' — 0" in Public Area

FIXTURE: Tellers' Area, Litecontrol Luminous Plastic Grid Louver Ceiling, with 2' x 4' louver panels, rapid start strip fixtures on 3' — 0" centers.

Public Area, No. 4384-RS-PG plastic grid louver recessed fixtures, 4' x 4'.

INTENSITY: Tellers' Area, average 50 footcandles in service. On Tellers' counters, average 75 footcandles in service. Public area, average 75 footcandles in service.

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Current Recommended Practice For Sports Lighting

Prepared by the Committee on Sports and Recreational Areas of the Illuminating Engineering Society

FOREWORD

This report is a complete revision of the 1950 "Current Recommended Practice for Sports Lighting" and is the result of a continuing study of current practice, existing installations, and standards in the sports lighting field. New features of this revised Practice include layouts for 18 new minor sports, material on TV production, new footcandle values and new recommended layouts. The layout recommendations presented here do not represent all that might be considered acceptable, but they do reflect the most satisfactory and practical components of all plans heretofore presented to and studied by the Committee.

SPORTS AND RECREATIONAL AREAS LIGHTING COMMITTEE

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Reprints of this report, together with index and cover, will be available in the near future and may be obtained through the IES Publications Office.

Table I—Current Illumination Recommendations.

	Average Horizontal Footcandles in Service*	
	Target	*Shooting Line*
Archery		
Tournament	10**	10
Recreational	5**	5
Badminton		
Tournament	30	
Club	20	
Recreational	10	
Baseball	*Infield*	*Outfield*
Major League	150	100
AA and AAA League	70	50
A and B League	50	30
C and D League	30	20
Semi-Pro and Municipal League	20	15
Recreational	15	10
Class I and Class II Junior League	40	30
On seats during game	2	
On seats before and after game	5	
Basketball		
College and Professional	50	
College Intramural and High School with Spectators	30	
College Intramural and High School without Spectators	20	
Recreational (outdoor)	10	
	On Land	*150 feet from shore*
Bathing Beaches	1	3**
Billiards	*On Table*	
Tournament	50	
Recreational	30	
General Area	10	

Bowling†	*Approaches*	*Lanes*	*Pins*
Tournament	10	20	50**
Recreational	10	10	30**

Bowling on the Green		
Tournament	10	
Recreational	5	
Boxing or Wrestling		
Championship, Professional, Amateur — Ring	500 / 200 / 100	
Seats during bout	2	
Seats before and after bout	5	

Casting	*Pier or Dock*	*Target*
Bait	10	5**
Dry Fly	10	5**
Wet Fly	10	5**
Croquet		
Tournament	10	
Recreational	5	

Curling	*Tees*	*Rink*
Indoor	20	10

Football (Regulation and Rugby)	
Index: Distance from nearest sideline to the farthest row of spectators†	
Class I: over 100 feet	100
Class II: 50 feet to 100 feet	50
Class III: 30 feet to 50 feet	30
Class IV: Under 30 feet	20
Class V: No fixed seating facilities	10
Six-Man Football	
High School or College	20
Jr. High School or Recreational	10
Golf Driving Range	
General on the Tees	10
At 200 Yards	5**
Golf Putting Greens	10
Gymnasiums	
Exhibitions, Matches	30
General Exercising and Recreation	20
Assemblies	15
Dances	5
Locker and Shower Rooms	20
Handball	
Tournament	30
Club	20
Recreational	10
Hockey	
Field	20
Ice	
College or Professional	50
Amateur	20
Recreational	10

	Average Horizontal Footcandles in Service*
Horseshoes	
Tournament	10
Recreational	5
Lacrosse	
High School or College	20
Quoits	5
Playgrounds	5
Racing	
Bicycle	20
Dog	30
Horse	20
Motor (Midget Auto or Motorcycle)	20
Rifle and Pistol Range	
On Target	50**
Firing Point	10
Range	5
Roque	
Tournament	20
Recreational	10
Shuffleboard	
Tournament	10
Recreational	5
Skating	
Roller Rink	5
Ice Rink	5
Lagoon, Pond or Flooded Area	1
Skeet Shoot	
Target, Surface at 60 feet	30**
Firing Point, General	10
Ski Slope Practice	3
Soccer	
Professional and College	30
High School	20
Recreational	10

Softball	*Infield*	*Outfield*
Professional and Championship	50	30
Semi-Pro	30	20
Industrial League	20	15
Recreational	10	7

Squash	
Tournament	30
Club	20
Recreational	10
Swimming Pool	
General—Overhead	10
Underwater	
Outdoors, 60 lamp lumens per square foot of surface	
Indoors, 100 lamp lumens per square foot of surface	

Tennis	*Lawn*	*Table*
Tournament	30	50
Club	20	30
Recreational	10	20
Trap Shoot		
Target at 150 feet	3**	
Firing Point—General	1	
Volleyball		
Tournament	20	
Recreational	10	

* On playing surface.

** Vertical surface.

† It is generally conceded that the distance between the spectators and the play is the first consideration in determining the class and lighting requirements. However, the potential seating capacity of the stands should also be considered and the following ratio is suggested: Class I for over 30,000 spectators; Class II for over 10,000 to 30,000; Class III for 5,000 to 10,000; and Class IV for under 5,000 spectators.

‡ Levels shown are based on visual considerations. Otherwise for public attraction and increased business considerations, practice is as follows:

Class	*Approaches*	*Lanes*	*Pins*
Tournament	70	100	200 Vertical
Recreation	50	70	150 Vertical

1. Introduction

1.1—*General*—(a) We have witnessed an unparalleled growth in sports and recreational lighting. Baseball, with its various leagues, has probably led the way to public acceptance for the lighting of practically every outdoor sport. This is evidenced by more and more lighted football fields, softball diamonds, golf driving ranges, and a host of sport and recreational play areas for player and spectator night participation.

(b) The lighting of areas used for various sports activities, especially those located outdoors, involves problems not encountered in other fields of lighting. Some of these problems, including, for example, the selection of proper floodlight locations, aiming techniques, and provisions for multiple uses of an area and its lighting facilities have not previously been covered by other Illuminating Engineering Society recommended practices.

1.2—*Purpose*—The purposes of this report are to aid in the design of new lighting systems and in the evaluation of existing installations.

1.3—*Content*—The text of the report consists of four basic parts: (1) recommended footcandle levels satisfactory to both players and spectators, (2) quality requirements prerequisite to good visibility, (3) recommendations of floodlight types, mounting heights, and mounting locations for specific sports, and (4) layouts of typical and existing illustrative sports lighting installations which conform to current good practice.

1.4—*Scope*— This recommended practice covers all forms of sports from the so-called major professional sports, such as baseball and football, to the recreational and playground sports, such as horseshoe pitching and croquet. It also includes recommendations for the lighting of gymnasiums and other interior areas specifically designed for sports activities, such as squash, handball, and bowling.

2. Factors of Good Illumination

2.1—*Illumination Levels*— (a) It is important that levels of illumination be sufficient for comfortable and accurate seeing and to enable (1) the players to perform their visual task and (2) the spectators to follow the course of the play.

(b) In those sports where large numbers of spectators are expected, as in large football and baseball stadiums, the illumination level is determined by the amount required for the spectators, in the row of seats farthest removed from the playing area, to follow the course of play. This condition may require several times the amount of light found satisfactory for the players. The illumination levels suggested by Table I are those which are currently considered minimum values of good practice, taking into consideration both players and spectators. In commercial establishments, much higher levels may be a profitable investment in increasing patronage and sales. It should also be borne in mind that nearly all sports evolved under daytime levels and that they can usually be played best and enjoyed most under these levels.

(c) *It is important to note that the illumination values in Table I are, in most cases, stated as average horizontal footcandles maintained in service.* It is recognized that the vertical component of the illumination on the playing area is important in most sports. Particularly in the "aerial" games, both players and spectators rely, to a considerable degree, on the vertical illumination on or near the playing area and, in some cases, well above the playing area. The same is true of movies and television, for the normal viewing position. In full recognition of the importance of *vertical* illumination, the recommended footcandle values for most sports and recreational areas are given in terms of horizontal illumination for two reasons: (1) values of horizontal footcandles are much less complicated to compute and measure in the field, and (2) the vertical components of illumination have been found adequate when the horizontal illumination meets the values in Table I, and when lighting equipment of the proper type (IES type distribution) is positioned at mounting heights and locations conforming to accepted good practice. Unless otherwise noted, the recommended values in this table are horizontal footcandles on the playing surface, or for "aerial" sports, horizontal footcandles on a plane 36 inches above the ground or floor.

2.2—*Movie and Television Lighting Requirements*—(a) When expanding the audience of athletic events by television or by recording the events on motion picture film, it is usually required that special attention be given to lighting. Lighting layouts that provide a high photographic quality of light are necessary. Definite consideration should be given to the type of sport and playing conditions in designing this lighting. Events requiring great depth of field will obviously require higher lighting levels.

(b) With present technology, 60 footcandles incident from the camera viewing direction is usually desired. This figure may vary depending upon the lens opening, the type of pick-up tube or film, color or black and white, and other circumstances peculiar to the athletic event. Care should be taken to ensure proper contrast between athletes; equipment used in the sporting event, such as balls, bats, uniforms, etc.; and the background. Normal brightness ratios for television pickup should be on the order of 20:1. If this brightness ratio is exceeded there will be accompanying loss of detail in highlights and shadows. When the brightness ratio is less than 20:1, contrast and resultant differentiation between objects is lessened. Placement of lighting equipment to provide light from at least two different directions is suggested to model participants. This modeling light can easily provide the brightness difference which will differentiate objects from their background.

(c) An incident exposure meter is the simplest guide to a photographer wishing to know what pictures can be photographed successfully in any specific situation.

(d) The quantitative lighting plans listed in Appendix E are designed to meet the visual requirements of players and attendant spectators, as described in this text, and are not necessarily adequate for motion picture or television photography.

2.3—*Quality of Illumination*

2.3.1—*General*—The quality of lighting, whether daylight or electric light, is highly important in providing good seeing conditions. *Glare, uniformity, and direction are the most significant*

Approved by the Council of the Illuminating Engineering Society, April, 1960. A Transaction of the IES.

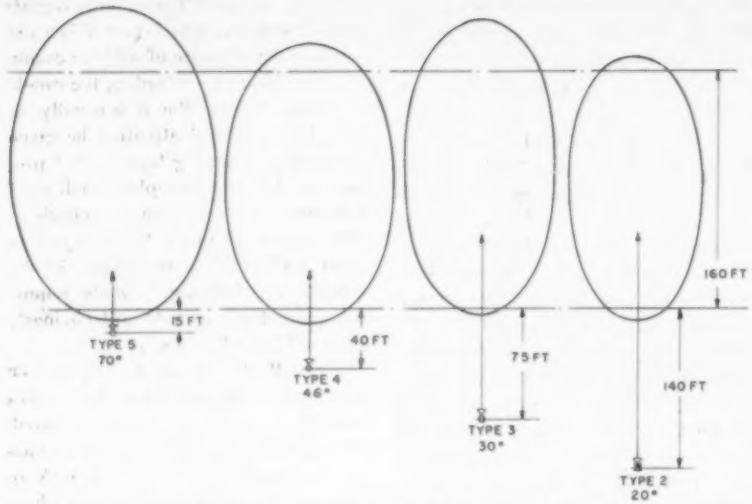


Figure 1. To maintain same beam pattern with varying distances from area to be lighted, beam spread must be reduced. (Mounting height is as recommended in mounting height chart, page 102.)

factors in determining the quality of illumination.

2.3.2—*Glare Control*—A floodlight is inherently a glare source, therefore, one of the primary tasks of the illumination designer should be to reduce the objectionable effects of glare to a minimum. The basic factors with which the designer may accomplish this task are: proper beam spread, adequate mounting heights, proper luminaire locations, and proper floodlight aiming.

2.3.2.1—*Beam Spread*—As the distance from the floodlight to the area to be lighted increases, the beam spread of the floodlight used should be decreased (see Fig. 1). The use of a floodlight with too great a vertical beam spread for a particular application can result in glare and ineffective utilization of available light (Fig. 2).

2.3.2.2—*Mounting Height* — Recommended minimum mounting heights are shown on the recommended layouts. Where for physical or economic reasons it is considered necessary to utilize lower mounting heights, the possibility of objectionable glare should be considered (see Fig. 3). For floodlighting applications, the following basis may be used to determine mounting heights which are minimum from the standpoint of glare: (1) *The angle between the horizontal playing surface and a line drawn through the lowest mounted floodlight and a point ⅓ the distance across the playing field should not be less than 30 degrees,* and (2) in addition to meeting the requirement above, *the minimum mounting height should not be less than 20 feet for ground sports and 30 feet for aerial sports.* See Fig. 4.

2.3.2.3—*Luminaire Location* — **(a)** The effects of glare are diminished as the luminaires are removed from the normal lines of sight of players and spectators. The angle between the luminaire and the normal line of sight depends upon both the distance of the luminaire from the observer and the luminaire's mounting height.

(b) The brightness of floodlights, particularly narrow beam types, is lower as they are viewed at increasing angles to the axis of the beam. For this reason, particular emphasis should be placed on location and aiming so that, within practical limits, floodlights are not directed along normal lines of sight of spectators or players (see Fig. 5).

(c) The recommended layouts show luminaire locations which reflect balanced judgment with regard to providing light from the proper direction, and at the same time locating the luminaires out of the normal lines of sight. Where physical obstructions require changes from these typical locations, all lines of sight of both players and spectators should be carefully evaluated in determining the new locations of the luminaires.

(d) With indoor applications, where fixed equipment is mounted on or near the ceiling, two angular regions are involved: (1) the angle from the vertical within which the lamps are not directly visible (called the shielded zone), and (2) the angle within which the lamps are visible (called the unshielded zone).

(e) Excessive brightness within the shielded zone may cause glare, particularly in large spaces. Brightness in the unshielded zone may cause direct glare or glare by reflection from the specular surfaces of bowling lanes, the surface of the water in swimming pools, or from polished floors and walls. In addition, the brightness of the luminaire in the unshielded zone

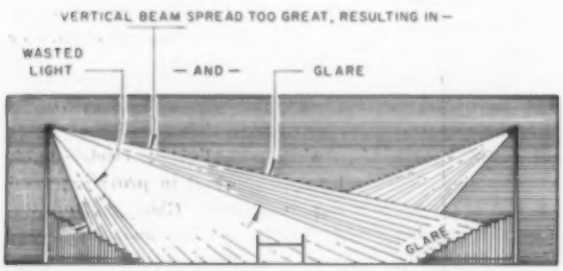


Figure 2. Floodlights with too great a vertical beam spread waste light and cause glare.

BEAM FROM LOW MOUNTED FLOODLIGHT
GLARE RESULTS FROM LOW POLE MOUNTING
TILTING DOWN OF LOW MOUNTED FLOODLIGHTS TO AVOID GLARE CAUSES HIGH BALLS TO DISAPPEAR FROM VIEW, DUE TO LOW CEILING

Figure 3. Sports floodlights mounted on poles that are too low either cause glare in the spectators' eyes or do not illuminate high-flying balls.

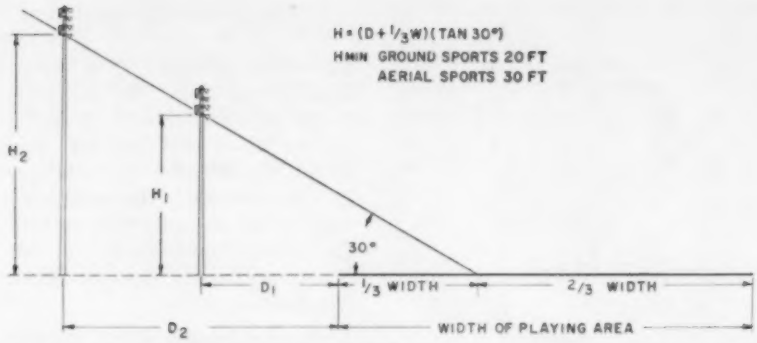


Figure 4. For adequate mounting heights, a line drawn from a point one-third the distance across the playing field to the lowest mounted floodlight should form an angle with the horizontal of not less than 30 degrees. In addition, minimum height for ground sports should not be less than 20 feet; for aerial sports, not less than 30 feet.

may cause discomfort or even disability glare if players or spectators look upward. This possibility is minimized by so locating the luminaires that they are moved as far as possible from the normal line of sight and/or by using low brightness sources.

2.3.2.4—*Luminaire Brightness Reduction*—**(a)** In the many sports where light must come into the playing area from many different locations, it is not always possible to remove all of the luminaires from the normal lines of sight of both players and spectators. Where this situation exists, the use of glare shields or some form of louvering (see Fig. 6) should be considered to reduce the high brightness of excessive spill light which might cause discomfort to spectators, or even to inhabitants of the surrounding area. The annoyance of light spilling into the region surrounding the playing area is often overlooked in the design of a sports lighting installation.

(b) Both glare shields and louvers can be designed to control only that light at certain angles which might cause annoyance. It is not necessary that such a device block all of the spill light or excessively reduce the light output of the luminaire. However, the amount of light reduction will depend upon the particular louver design employed. For any specific louver-floodlight combination, some reduction in the published lumen output of the floodlight alone may have to be allowed for in the installation design. It is recommended that a qualified engineer be consulted before attempting a specific louver design.

2.3.2.5—*Surround Brightness* — Increasing the brightness of the surround reduces the brightness difference between luminaire and surround and improves visibility. This can be done very effectively for indoor sports by finishing the walls and ceilings of the rooms in light colors. Control of the surround brightness is much more difficult in outdoor locations; however, a great deal can be done in this regard. Adequate light in the stands and light-colored fences, together with provisions for providing some illumination on the ground immediately around the playing field, aids considerably in improving the surround conditions.

2.3.3—*Uniformity* — Reasonable uniformity of illumination over a playing area, and throughout the entire space above the playing area, is required for satisfactory seeing by players and spectators. Sharp changes in the illumination level in the space above the playing area through which the ball may travel will result in making a fast moving ball appear to accelerate as it passes from a light to a dark space. This occurs when there is inadequate overlap of floodlight beams. Such a condition distorts the player's judgment of ball trajectory. Expressed in terms of horizontal illumination, *acceptable uniformity occurs when the ratio of maximum to minimum illumination does not exceed three to one within a specified area* for those sports in which play is skillful, the visual task is severe, or there are likely to be spectators.

2.3.4—*Direction of Light*—**(a)** The brightness difference between an object and its surround, as well as the brightness difference between the various surfaces of an object, provide the contrast required for the eye to see. Since the visual tasks of the spectators and players involve seeing vertical surfaces

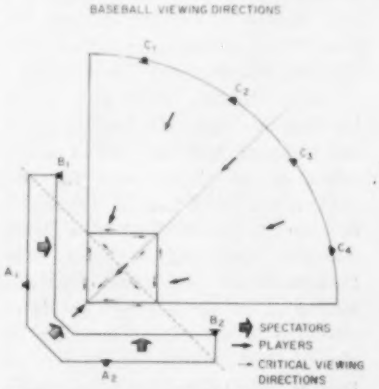


Figure 5. Where physical obstructions require changes from the recommended pole locations, an analysis should be made of possible lines of sight of both players and spectators before new positions are selected. Poles should never be located directly in line with critical viewing directions.

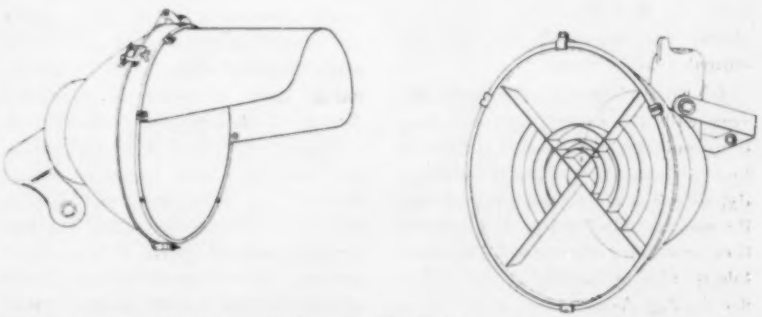


Figure 6. Properly designed glare shields (left) or louvers (right) can effectively eliminate, at certain angles, the high luminaire brightness that might cause annoyance either inside or outside the playing area.

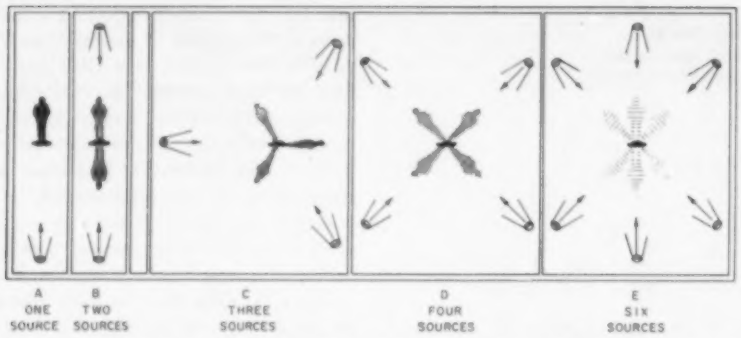


Figure 7. Shadows occur on floodlighted fields but their effect is minimized by proper aiming of lights. Note how an increase in the number of light sources (from A to E) reduces the effects of shadows.

as well as horizontal surfaces, it is essential to provide adequate illumination on both the horizontal surfaces and the vertical surfaces of a solid object. However, as the objects of view in sports are not flat-faced solids, it is not essential to provide uniform illumination on all surfaces; in fact, semi-directional illumination provides shading and modeling which aids seeing. To eliminate harsh shadows, however, and to permit good visibility at any location in the playing area for both players and spectators, it is generally necessary to provide light from several different directions at each point throughout the area. Good directional quality of the lighting in a sports installation is not characterized by the absence of shadows (since the very nature of floodlighting tends to produce shadows) but rather by the number of shadows produced (Fig. 7).

(b) For unidirectional sports, such as bowling, driving golf balls, racing, handball, archery, etc., it is permissible and desirable to provide much higher footcandles from one direction. This makes it possible to locate the luminaires so that they are almost completely removed or shielded from the normal field of view.

(c) The aiming of the floodlights, even with the correct luminaire locations and mounting heights, determines to a large extent whether the uniformity, direction and candlepower toward the eye are satisfactory. For information concerning the correct fundamentals of aiming floodlights, see Appendix A, Fig. A-1.

2.4—*Maintenance*—See Appendix B.

3. Classification of Play

3.1—*Player Requirements*— Player requirements vary with the class of play. The *tournament* classification applies to the caliber of play as found in tournaments and exhibitions; the *club* classification applies to good, fast play; the *recreational* classification applies to amateur play for fun and relaxation.

3.2—*Spectator Requirements*— Spectator requirements for satisfactory seeing vary with the type of sport, distance from and orientation to the playing field. A stadium where the last row of spectators is several hundred feet away from the playing area must be lighted to a high level of illumination if the more remote spectators are to follow the play. If the spectator section is limited to small bleachers along the sides of the field, the illumination level which will provide good playing conditions will adequately serve the spectators.

3.3—*Commercial Requirements*— It is recognized that many sports are played or watched in commercial establishments where levels of illumination must be based on additional factors of atmosphere, attraction value, and better than adequate seeing. This has been true in major league baseball for some time, but applies also, for example, to racing, bowling, archery, and all sports in commercial arenas. Since recommended levels based on commercial considerations depend on many factors which require further study, such considerations are not included in the values in Table I.

4. Equipment Classification

4.1—*General*—(a) The optical characteristics of the luminaire affect, to a large extent, such important factors as direct and reflected glare, shadows, distribution and diffusion. Because there are wide variations in these optical characteristics, the selection of the correct luminaire for a particular application deserves careful consideration.

(b) Luminaires should be designated so as to describe the manner in which the light from the lamp is controlled by the lighting unit, the degree of concentration of zonal lumens (concentration of light), and mechanical details. Since in sports and recreational area lighting there are both outdoor and indoor lighting problems, the lighting equipment should necessarily be selected to qualify for the service designated. There are, therefore, separate designations and classifications pertaining to outdoor and indoor lighting equipment.

4.2—*Outdoor Floodlight Luminaire Designations*

4.2.1—*Floodlight Classes*—(a) *Enclosed Heavy-Duty (HD).* This class is weatherproof, having a substantially constructed housing into which is placed a separate and removable reflector. The assembly is enclosed by a weatherproof hinged door with cover glass, which provides an unobstructed light opening at least equal to the effective diameter of the reflector.

(b) *Enclosed Ground-Area and General Purpose (GP).* This class is weatherproof and so constructed that the housing forms the reflecting surface. The assembly is enclosed by a cover glass.

(c) *Ground-Area Open (O).* This class provides a weatherproof enclosure for the lamp socket and housing. No cover glass is required.

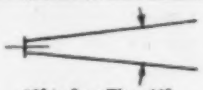
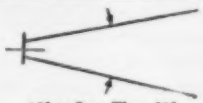
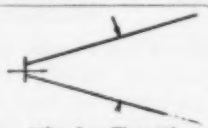
(d) *Ground-Area Open with Reflector Insert (OI).* This class is weatherproof and so constructed that the housing forms only a part of the reflecting surface. An auxiliary reflector is used to modify the distribution of light. No cover glass is required.

4.2.2—*Beam Data*—The choice of the light distribution of a luminaire may

be selected and designated by type as shown in Table IIa. *Beam spread is the average of the horizontal and vertical spreads,* and for the purpose of classifying floodlights, the method of determining and recording the beam spread should be in accordance with the adopted report of the IES Committee on Testing Procedures for Illumination Characteristics.*

Table II—Outdoor Floodlight Luminaire Designations.

a. Beam Spread

Type	Photometric Designation	Open or Closed	Beam Spread in Degrees
1	Very Narrow Beam	Enclosed	 10° to Less Than 18°
2	Narrow Beam	Enclosed	 18° to Less Than 29°
3	Medium Beam	Enclosed	 29° to Less Than 46°
4	Medium Wide Beam	Enclosed or Open	46° to Less Than 70°
5	Wide Beam	Enclosed or Open	70° to Less Than 100°
6	Very Wide Beam	Enclosed or Open	100° and Up

b. Minimum Beam Efficiency—Per Cent.

Type	Enclosed Heavy Duty Class HD		Enclosed Ground-Area and General Purpose Class GP		Open Ground-Area Class O or OI	
	Less Than 17-Inch Diameter	17-Inch Diameter and Over	Less Than 17-Inch Diameter	17-Inch Diameter and Over	Less Insert Class O	With Insert Class OI
1	30	35	34	35	—	—
2	34	40	36	36	—	—
3	40	43	39	45	—	—
4	44	47	42	50	—	35
5	50	55	46	50	—	40
6	—	—	—	—	55	60

4.2.3—*Method of Designation*—Floodlights covered by the above may be designated as Heavy Duty, Type 1, 2, 3, etc., General Purpose, Type 1, 2, 3, etc., and Open Type 4, 5, 6, etc.

4.2.4—*Performance Characteristics*—In addition to beam types and floodlight class characteristics, the National Electrical Manufacturers Association's "Standards Publication for Floodlights" specifies the minimum beam efficiency that each class and type of floodlight should provide. The summary of photometric data in Table IIb is indicative of what can be expected from typical equipment.

4.3—***Reflectorized Lamps***—Lamps having integral reflectors are applied particularly to the minor sports. Outdoor types with heat resistant glass bulbs may be considered as physically corresponding to the general purpose category. Substitution of reflectorized lamps for floodlighting luminaires should be on the basis of equal lumens delivered in service. See manufacturers' publications for photometric data and application.

4.4—***Interior Lighting Luminaire Design***—**(a)** Interior lighting luminaires may be classed into five different types, based on the manner in which light is distributed from the luminaire. These classifications apply to all interior luminaires regardless of the type of source the luminaire employs. The type designations do not in themselves imply quality of lighting or luminaire efficiency. The figures given in Table III indicate the percentage of the total luminaire light output emitted upward and downward.

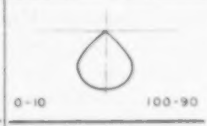
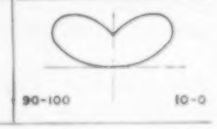
(b) Direct luminaires may be further classified so as to denote concentration of zonal lumens (concentration of light), such as concentrating, medium spread and wide spread.

4.5—***Photometric Data***—The method of determining and recording photometric data should be in accordance with the adopted report of the IES Committee on Testing Procedures for Illumination Characteristics.**

*"I.E.S. Guide for the Photometric Testing of Floodlights of 10 to 160 Degrees Total Beam Spread," ILLUMINATING ENGINEERING, Vol. XLVI, No. 3 (March, 1951).

**"I.E.S. Guide for Reporting General Lighting Equipment Engineering Data," ILLUMINATING ENGINEERING, Vol. LIV, No. 8 (August, 1959).

TABLE III—Interior Luminaire Designations.

Type (CIE Classification)	Approximate Distribution of Light Emitted by Luminaire	
	Upward Per Cent	Downward Per Cent
Direct		
	0-10	100-90
Semi-Direct		
	10-40	90-60
General Diffuse		
	40-60	60-40
Semi-Indirect		
	60-90	40-10
Indirect		
	90-100	10-0

5. Lighting Systems

5.1—*General*—There are three basic types of light sources in use today: incandescent filament, fluorescent and mercury. Each type of source has certain advantages and certain disadvantages, and the selection of one source over the others will depend upon the particular requirements of the installation under consideration, the economics (see Section 8) and, to some extent, the personal preference of the system designer or owner. The layouts indicated in the floodlight application guide (Appendix E) are all based on the use of incandescent filament lamps. Other sources may be used which will provide equivalent illumination.

5.2—*Incandescent Filament Lighting*—(a) The principal advantages of an incandescent filament system are low initial cost, good color rendition, and light control, while its primary disadvantages are shorter lamp life and lower lumens-per-watt efficacy as compared with the mercury and fluorescent systems. An industrial, high bay type reflector with an incandescent lamp is commonly used for gymnasium lighting because of the relatively high mounting heights normally encountered. The use of ventilated luminaires aids in reducing the amount of maintenance required. Disconnect lowering devices may be found to be advantageous, particularly in those instances where there are limited funds for extensive maintenance equipment and high mounting heights make the luminaires virtually inaccessible.

(b) Mounting luminaires along catwalks may also ease the maintenance problem. Wire guards are recommended for use with open type luminaires to provide protection for the lamps.

5.3—*Fluorescent Lighting* — A fluorescent lighting system provides high lumens per watt, long lamp life, low brightness, and good color rendition, but is generally higher in initial cost than its incandescent filament counterpart. For indoor applications, louvers are desirable for use with fluorescent luminaires to provide lamp protection as well as maximum shielding. The semi-direct type luminaire is recommended for use where the luminaire is mounted in reasonably close proximity to the ceiling to reduce brightness differences and to provide adequate diffusion over the area. Fluorescent luminaires are applicable for certain outdoor sports and recreational areas where mounting heights are relatively low and required projection distances are short. Typical applications would include bowling, curling, tennis and similar sports.

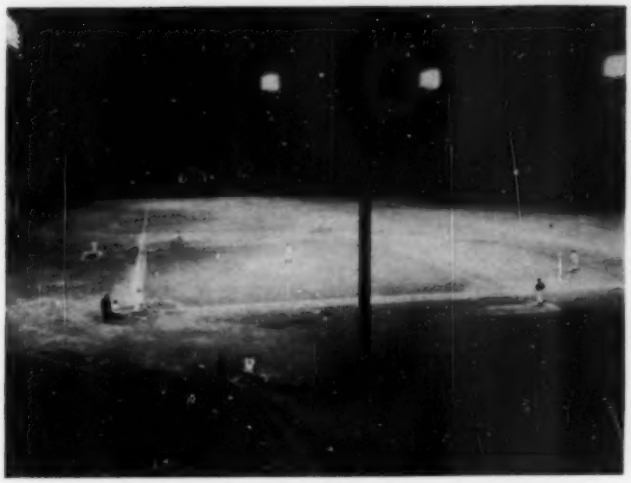
5.4—*Mercury Lighting*—A mercury system will also provide the advantages of long lamp life and high luminous efficacy. In addition, it is more adaptable to use with disconnect suspension devices for ground maintenance than is a fluorescent system. Like fluorescent, the mercury installation is higher in initial cost than an incandescent filament system, and a considerable number of hours of operation per year is required to economically justify its use. There are two characteristics of a mercury system which should be considered in its utilization for sports lighting. The first is the inability of the mercury lamp to restart following a power interruption without several minutes of cooling time. This feature generally necessitates the addition of some incandescent equipment to the mercury system to provide emergency stand-by illumination, particularly over the spectator areas. The second is the absence of red in the spectrum of the mercury arc which tends to distort the appearance of certain colors and particularly that of the human complexion. The use of a combination mercury-incandescent system, on a one-to-one lumen ratio, or of the improved-color mercury lamp is recommended to produce a satisfactory color rendition.

5.5—*Special Design Considerations*—In selecting either a mercury or a fluorescent lighting system for use in a sports or multipurpose area, some important factors should be given special consideration: (1) Both mercury and fluorescent light sources, when operated singly on alternating current circuits, produce a noticeable flicker on rapidly moving objects. This condition, stroboscopic effect, may be minimized by connecting lamps or luminaires on alternate phases of a three-phase supply, or by employing two-lamp lead-lag or series sequence start ballasts where available. (2) In multipurpose areas, if a quiet surround is an important factor, the possible objectionable disturbance resulting from ballast "hum" should be considered. Remote mounting of the fluorescent or mercury ballasting equipment may be desirable. (3) When fluorescent lamps are used outdoors, they should be protected from the wind in order to maintain maximum light output.

6. Lighting for Outdoor Sports

6.1—*Representative Layouts* — Illumination levels obtained with the illustrative layouts presented in this report equal or surpass the current footcandle values recommended for the class of play under consideration. The recommended values are intended to be minimum values. In any installation, the illumination obtained is subject to unpredictable variations in installation, aiming, luminaires, lamps, voltage at the lamps and atmospheric transmission. Some typical installations for several outdoor sports areas are shown in Figs. 8-15.

Typical Outdoor Installations



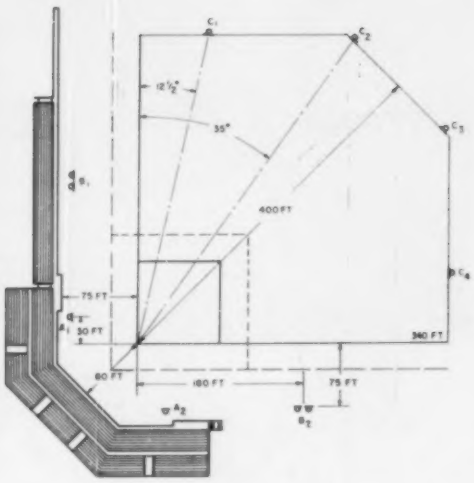


Figure 8. Typical Baseball Installation—Class C. Footcandles Maintained in Service—Infield, 44; Outfield, 23.

No. of Poles	Mounting Height (Feet)	Floodlights								Total Load (KW)
		Total No.	No. Per Pole			Type	Class	Beam (Degrees)	Efficiency (Per Cent)	
			A	B	C					
10	95	240	12	8	10	5	GP	76	58	418
			12	40	14	3		32	49	

Lamps: 1500-watt PS-52 clear, general service, operated at 10 per cent over rated voltage.

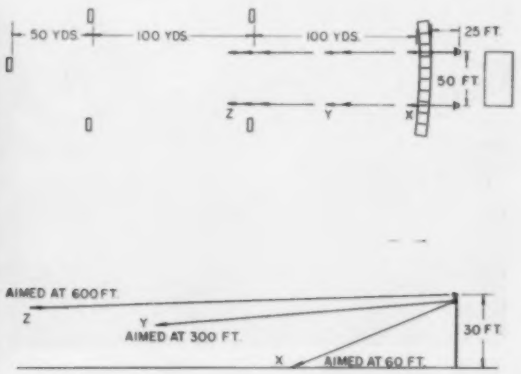


Figure 9. Typical Golf Driving Range. Footcandles Maintained in Service: Tees—10, at 200 Yards—5 Vertical.

No. of Poles	Mounting Height (Feet)	Floodlights					
		Total No.	No. Per Pole	Type	Class	Beam Spread (Degrees)	Efficiency (Per Cent)
2	30	X-2	1	5	GP	78	58
		Y-4	2	3	GP	34	49
		Z-6	3	1	GP	11	30

Lamps: X and Y—1500-watt, PS-52, clear, general service; Z—1000-watt G-40 clear floodlight service lamp. Operated at rated voltage.

Typical Outdoor Installations

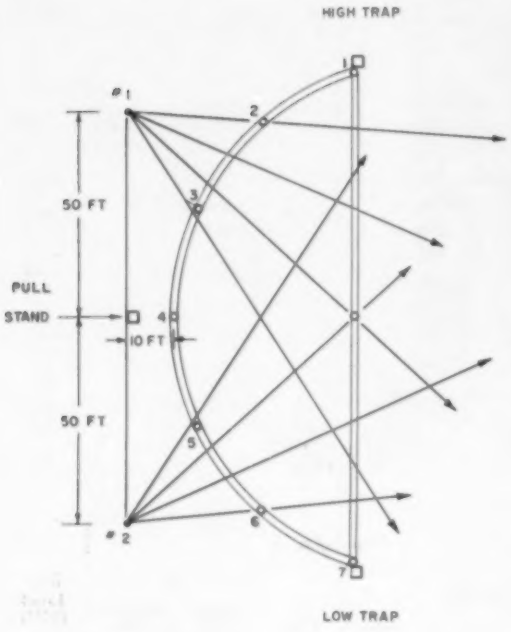


Figure 10. Typical Skeet Installation. Footcandles Maintained in Service: Target (vertical surface at 60 feet)—30, Firing Point—10.

No. of Poles	Mounting Height (Feet)	Floodlights					
		Total No.	No. Per Pole	Type	Class	Beam Spread (Degrees)	Efficiency (Per Cent)
2	25	8	4	2	GP	24	45

Lamps: 1500-watt, PS-52, clear, general service, operated at rated voltage.

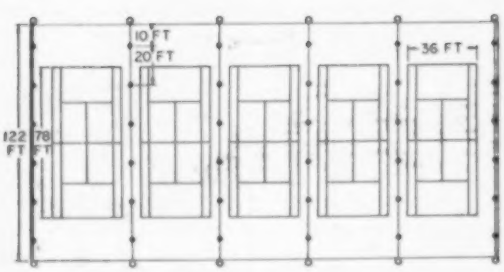
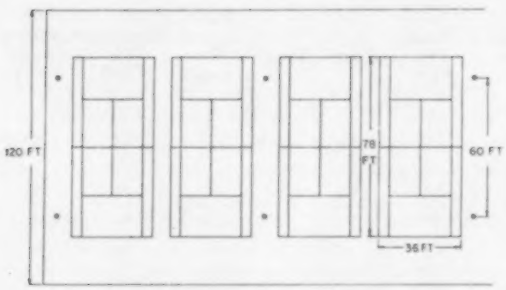


Figure 11. Typical Tennis Installation—Overhead Suspended Luminaires. Footcandles Maintained in Service—10.

No. of Poles	Mounting Height (Feet)	Floodlights				
		Total No.	No. Per Messenger	Type	Distribution	Efficiency (Per Cent)
12	30	36	6	Industrial High Bay	Wide	78

Lamps: 1500-watt, PS-52, clear general service operated at rated voltage.

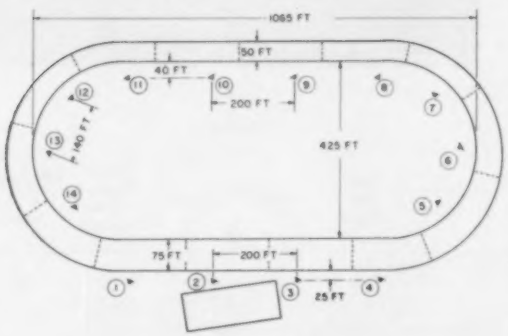
Figure 12. Typical Tennis Installation—Pole Mounted Floodlights. Footcandles Maintained in Service—10.



No. of Poles	Mounting Height (Feet)	Floodlights					
		Total No.	No. Per Pole	Type	Class	Beam Spread (Degrees)	Efficiency (Per Cent)
12	30	60	3-6	5	GP	78	58

Lamps: 1500-watt, PS-52, clear, general service, operated at rated voltage.

Figure 13. Typical Half-Mile Race Track Installation.

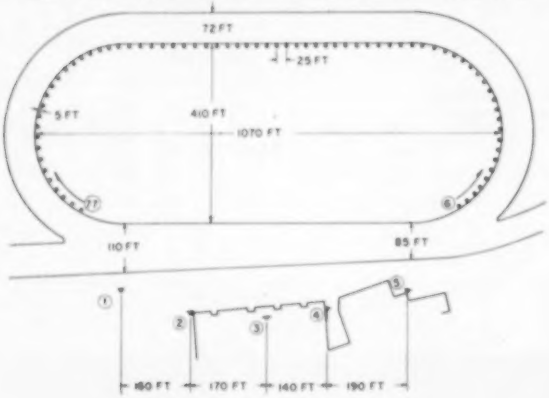


Pole No.	Floods Per Pole	Class	Type	Beam Spread (Degrees)	Efficiency (Per Cent)	Mounting Height (Feet)
1–4	30	GP	3	32	49	80
5, 14	19	GP	3	32	49	60
	5	GP	4	57	54	60
6–13	15	GP	3	32	49	60
	5	GP	4	57	54	60
Total	328	Total Load—571 KW				

NOTES: (1) All lamps are 1500-watt, PS-52, clear, general service lamps operated at 10 per cent over rated voltage.
(2) Calculated average illumination level, footcandles maintained in service: home stretch—30, back stretch and turns—20.
(3) To reduce glare, floodlights cover area two-thirds ahead and one-third back of pole locations with crossarms oriented with respect to center of area.

Typical Outdoor Installations

Figure 14. Typical Half-Mile Race Track Installation.



Pole No.	Floods Per Pole	Class	Type	Beam Spread (Degrees)	Efficiency (Per Cent)	Mounting Height (Feet)
1, 5	16 8	GP GP	3 5	32 76	49 58	80
2, 4	24	GP	2	26	44	80
3	32	GP	2	26	44	80
6–77	2	0	6	136	72	20
Total	272	Total Load 473—KW				

NOTES: (1) All lamps are 1500-watt PS-52, clear, general service lamps operated at 10 per cent over rated voltage.
(2) Calculated average illumination level, footcandles maintained in service—20.

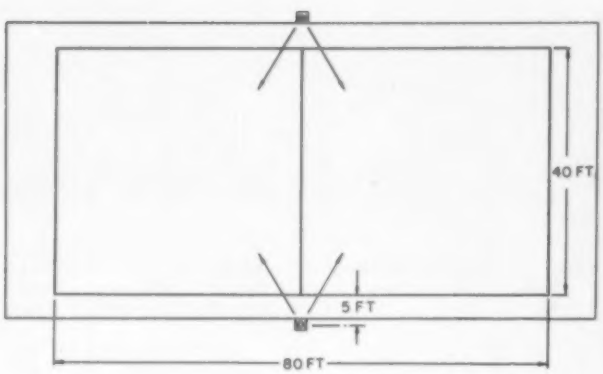


Figure 15. Typical Volleyball Installation. Footcandles Maintained in Service—10.

No. of Poles	Mounting Height (Feet)	Floodlights					
		Total No.	No. Per Pole	Type	Class	Beam Spread (Degrees)	Efficiency (Per Cent)
2	30	4	2	5	GP	78	58

Lamps: 1500-watt, PS-52, clear, general service, operated at rated voltage.

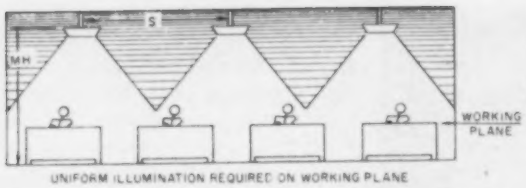
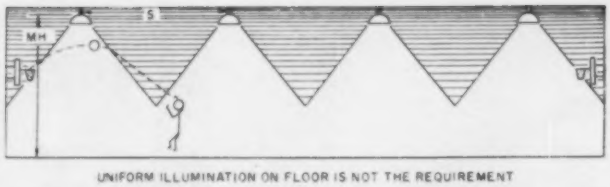


Figure 16. For many interior sports lighting installations uniform illumination on the floor is not the requirement.



Adequate vertical distribution is required to the maximum height the object might travel during normal play.

7. Lighting for Indoor Sports

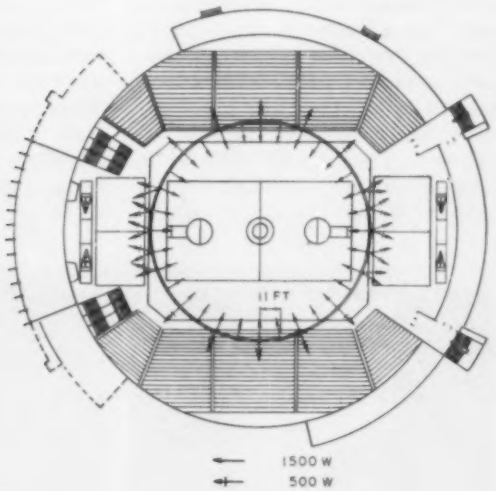
7.1—*General*—(a) The walls and ceilings of interiors used for sports provide a means for controlling background brightnesses, assist in diffusing the available light, and make possible a variety of convenient lighting equipment arrangements. The design and calculation procedures for interior sports lighting are similar to those followed in the design of any interior lighting system with one exception. The maximum luminaire spacing for interior type units is generally given as a ratio of the spacing to mounting height. This ratio is intended to provide uniform illumination on a plane 30 inches above the floor. In designing an interior sports lighting installation, where the object to be viewed may be at floor level, near the ceiling, or at any level in between, special consideration should be given to spacing the luminaires closely enough to obtain adequate vertical distribution to the maximum height to which the object might travel in normal play (see Fig. 16). This will permit the observer to estimate, more accurately, the velocity and trajectory of the object at all times, within the limits of his own capabilities, and prevent the object in question from being "lost" above the ceiling of the lighted area. As with outdoor sports, observers have no fixed visual axis or field of view, and during the course of play, the ceiling and luminaires may frequently be included in the visual field.

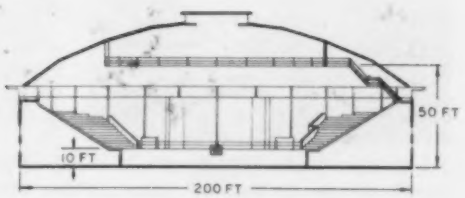
(b) Sports played indoors may be generally divided into two classes: (1) sports played within one general area, *i.e.*, gymnasiums, where the lighting is provided for all sports by one lighting system, and (2) sports played in an area designed and lighted expressly for that sport.

7.2—*Gymnasiums*

7.2.1—*General* — **(a)** The modern school gymnasium is a multi-purpose, as well as a multi-sport area, which can serve a variety of needs of the student body during the daytime, and in many instances, of the community at night. In addition to its varied athletic uses, the school gymnasium is often used for such activities as assemblies, dances, concerts, lectures and

Figure 17. Typical Gymnasium Installation.





	Mounting Height (Feet)	Floodlights					
		Total No.	Lamp Size (Watts)	Type	Class	Beam Spread (Degrees)	Efficiency (Per Cent)
Basketball	50	32	1500	5	GP	95	54
Volleyball Shuffleboard	40	8	500	6	OI	115	68
Bleachers	28 Avg.	14	500	6	OI	115	68

NOTES: (1) All lamps clear, general service, operated at rated voltage.
(2) Average illumination, initial footcandles: basketball—70, volleyball/shuffleboard—30, bleachers—12.

Figure 18. The desired illumination levels for the variety of functions in a gymnasium can be obtained by placing portions of a general lighting system on individual circuits.

Figure 19. Caution should be exercised in positioning luminaires relative to critical surfaces, such as glass basketball backboards, to avoid blinding direct and reflected glare.

community meetings. A typical lighting installation for this multi-purpose area is shown in Fig. 17. A choice of lighting levels may be desirable because of the wide divergence in seeing tasks that can be encountered. Such variations in the general illumination are most often achieved through circuiting, by placing portions of the total lighting system on separate circuits which can then be operated independently or in combination with other circuits to gain the illumination level desired (see Fig. 18). For special activities, such as dances, where the creation of a mood or an atmosphere is the primary lighting objective and quite low illumination values are desired, the most satisfactory results can often be achieved through the use of portable or temporary auxiliary lighting equipment, such as floodlights or reflectorized lamps, and colored filters.

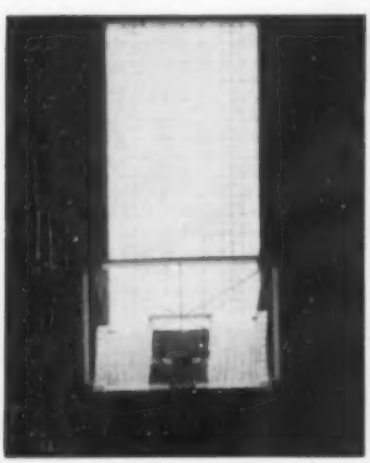
(b) For many high school installations, however, particularly where economy is a prime consideration, a single circuit, general lighting system supplying the recommended illumination level of 30 footcandles will answer the requirements of the majority of activities encountered.

(c) To prevent breakage, it may be necessary to cover luminaires with a protective cover or wire grid. This will reduce their efficiency and should be compensated for in the initial system design by multiplying the luminaire's efficiency by the average transmittance of the cover or grid.

7.2.2—*Basket Highlighting*—If it is considered desirable to provide increased illumination in the area immediately adjacent to the baskets of the basketball court, care should be taken to position those luminaires in such a manner as to avoid blinding reflections of the luminaires on the backboard. This problem is particularly serious where glass backboards are employed (see Fig. 19).

7.2.3—*Windows*—Windows in a gymnasium may be unsatisfactory in the distribution and amount of illumination they provide and undesirable if proper controls are not applied. In many instances windows can become a blinding glare source, for example, when they are located behind the baskets of a basketball court. They can create a very real hazard to players engaged in activities in the gymnasium (Fig. 20). The extent to which windows should be used will depend upon whether satisfactory environmental conditions are attained and upon the relative costs (building construction, equipment, controls and maintenance) of providing the recommended illumination levels from either daylighting or electric lighting, or a combination of both.

7.2.4—*Interior Finishes*—**(a)** Light-finished ceilings, walls and floors not only enhance the appearance of a gymnasium, but increase the utilization of light and improve visibility. Ceiling reflectances of 80 to 85 per cent are attainable on smooth surfaces



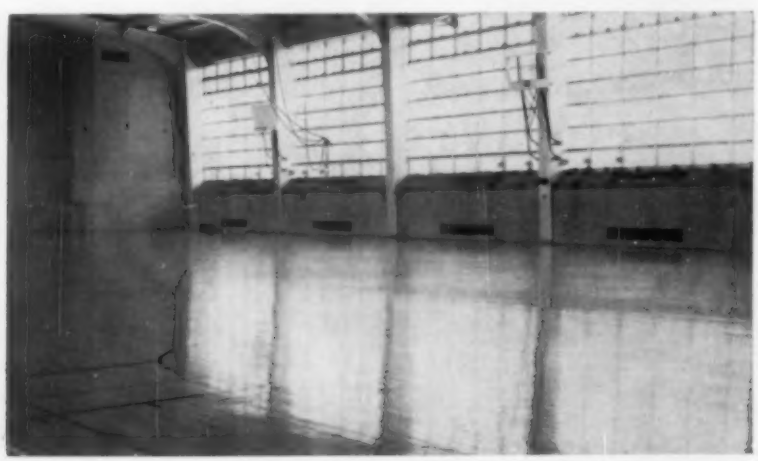


Figure 20. ***Caution:*** **(left) Windows behind glass backboards in the gymnasium can produce direct glare. (right) Unshielded windows in a gymnasium are a potential source of direct and reflected glare.**

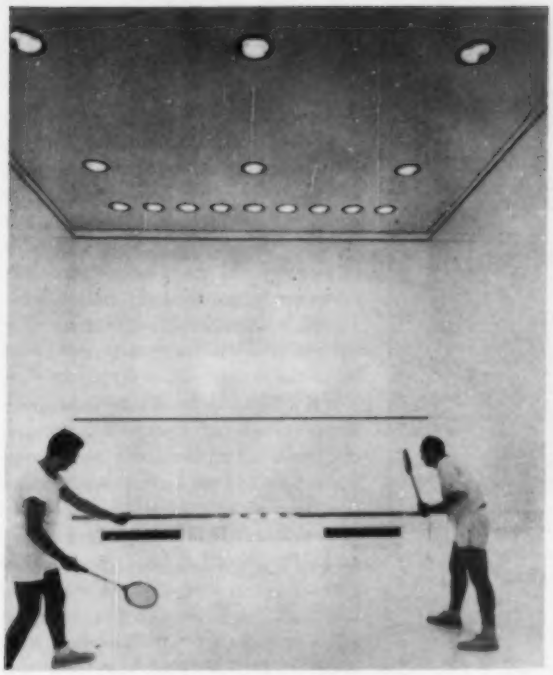


Figure 21. Good lighting design for aerial sports requires attention to overlapping luminaire beam patterns for adequate vertical illumination, as on the squash (left) and handball courts which are shown above.

with good grades of white non-glossy paint. The same paints on acoustical materials have somewhat lower reflectances because of the porous nature of these surfaces. However, perforated type tile permits the maintenance of both good reflectances and sound absorbing qualities when repainted, as there is relatively little tendency for the perforations to clog with paint.

(b) Walls of matte-glazed tile or other non-abrasive material are widely used in modern gymnasiums up to heights of approximately seven feet. Above this area, light-colored cinder blocks, brick, or wood paneling provide a wall reflectance in the desirable range of 50 to 60 per cent.

(c) Natural hardwood floors, sealed with a non-glossy finish, have reflectances of 15 to 30 per cent.

7.3—*Specialized Areas*—In areas designated expressly for a particular sport, the lighting system can be more readily tailored to the specific requirements of that sport than is possible in the multi-sport area.

7.3.1—*Aerial Sports* — With aerial sports such as badminton, basketball, handball, squash, tennis and volley ball, the type of action encountered during normal participation is such that the ceiling may be in the observer's field of view during a large portion of the playing period. Therefore, when planning general lighting installations for these sports, every effort should be made to select, locate and shield the light sources to avoid introducing glare in the observer's view. For these sports in particular, adequate overlapping of the luminaire beam patterns is imperative to ensure adequate vertical illumination over the entire height of the playing area (see Fig. 21).

7.3.2—*Low Level Sports* — Archery, billiards, bowling, fencing, curling,

Figure 22. Luminous ceiling in a billiard room.

Figure 23. Bowling alley has over 200 footcandles of illumination from combination of high output fluorescent and incandescent dome units.

shuffleboard, skating, swimming, boxing, wrestling, and other sports in which observers in the normal course of participation do not look upward, are called low level sports. General lighting may be planned more easily for these sports than for the aerial type, since luminaire brightness is less critical (see Figs. 22 and 23).

8. Design Factors

8.1—*General*—(a) The correct choice among the various design factors of luminaire type, lamp type, lamp voltage, wiring method, etc., depends upon a balancing of economic costs against such factors as appearance, relative safety, and reliability.

(b) The over-all cost for lighting should include: (1) an amortization of the first cost, (2) the cost of electrical energy consumed, (3) cost of lamp replacements, and (4) an estimate for maintenance expense exclusive of lamp replacement.

(c) Comparison of lighting systems on this basis, perhaps with different luminaires, or different wiring methods, may be made by means of a cost analysis. A true comparison should involve systems providing comparable quality and quantity of illumination.

8.2—*Lamp Voltage*—Many sports lighting installations are utilized for a comparatively small number of hours per year. In such cases, good economy dictates the operation of incandescent filament lamps at voltages above those for which they were designed. In general, operation of general service incandescent lamps at 10 per cent over rated voltage should prove economical when in use 200 hours or less per year, and 5 per cent overvoltage operation when annual use is from 200 to 500 hours. Where annual operation exceeds 500 hours, lamp operation at rated voltage is recommended. Operation at 10 per cent overvoltage increases light output by 35 per cent, power consumed by 16 per cent and reduces lamp life to approximately one-quarter of rated life. Operation at 5 per cent overvoltage increases light output 18 per cent, energy consumption 8 per cent, and reduces lamp life to about one-half of rated life.

8.3—*Choice of Equipment*—(a) Floodlights, due to their larger size, more elaborate mounting requirements, and in some cases cover glasses, are more expensive than normal indoor type luminaires. The use of floodlights is economically justified on any outdoor area where the light must be projected a considerable distance. The comparison can be readily calculated by methods outlined in Appendix C.

(b) Floodlights are available with beam spreads of various degrees and can be used economically to concentrate light on and near the playing area even when they must be mounted several hundred feet from the playing area. On the other hand, some of the playground sports such as horseshoe pitching, shuffleboard, etc., may in some cases be lighted by indoor type units suitably adapted to outdoor use.

8.4—*Choice of Beam Spreads*— Most open floodlights provide inherently wide beam spreads. Enclosed floodlights are available in a range of beam spreads from wide to narrow. *The choice of beam spread depends largely on the distance from the floodlights to the area to be lighted; the greater the distance, the narrower the beam spread for high utilization, efficiency and restriction of glare.* See Fig. 24. Conversely, when floodlights are located relatively close to the playing area, wide beam spreads can be used with good economy.

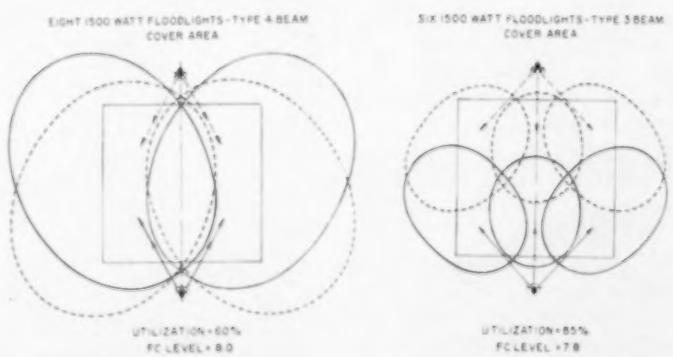

EIGHT 1500 WATT FLOODLIGHTS - TYPE 4 BEAM
COVER AREA
UTILIZATION = 60%
FC LEVEL = 8.0
SIX 1500 WATT FLOODLIGHTS - TYPE 3 BEAM
COVER AREA
UTILIZATION = 85%
FC LEVEL = 7.8

Figure 24. Selecting proper beam spread for specific applications results in better utilization and lower over-all costs. On the 100- by 100-foot area shown, eight Type 4 floodlights are required to produce about the same footcandle level obtained with six Type 3 floodlights of the same wattage. Mounting height is 60 feet in both cases.

8.5—*Open and Enclosed Floodlights*—The choice between open and enclosed floodlights depends chiefly on differences in cost and in rate of depreciation. Open floodlights cost less, but depreciate more rapidly due to collection of dirt, soot, etc., on reflecting surfaces and light sources. *It is generally accepted practice to allow a maintenance factor of 75 per cent for enclosed floodlights and 65 per cent for open floodlights when calculating the maintained footcandle level.* Although these factors are empirical, they are based on considerable experience. The cleanliness of the surroundings, the frequency of cleaning of the units and replacement of lamps will affect the maintenance factor to a considerable extent.

8.6—*Wiring*—(a) Outdoor floodlighting installations can be made with either overhead or underground distribution. From the standpoint of appearance and minimum interference, the underground system is more desirable where large playing areas are involved. The underground system may be made using either direct burial conductors or wire in conduit. While overhead distribution may be less expensive with regard to conductors, conduit and installation costs, additional items may be required, *e.g.*, extra poles to keep wires away from the playing area and guys on poles where there is a change in direction of feeders or where the feeders dead-end. The choice of installation to use will depend on local practice and should include a consideration of the economics and other factors such as appearance, safety and reliability.

(b) Some installations may justify a separate transformer on each pole or tower with primary wiring to each location. In smaller installations, it may be more economical to reduce the number of transformers by serving several locations from a single transformer through secondary wiring. This decision will also depend upon the rules and practices of the local utility company.

(c) The utility should, of course, be consulted as to the type of service available, whether primary or secondary, single-phase or three-phase, wye or delta. The rates for the various services should also be considered before a decision is made as to the preferred installation. Whether to wire one or more lighting units on each circuit is determined by local practice and economic considerations as limited by local and national code rules.

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APPENDIX A—Floodlight Aiming.

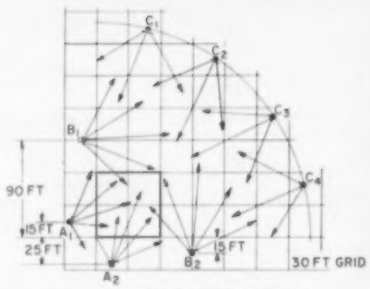
A-1—*General*—(a) In any sports lighting project, proper aiming of the luminaires upon installation is vitally important in order that the user may secure the full benefits of the quality that the manufacturer has built into his equipment, and that the engineer has provided in his layout. Each luminaire must be carefully directed to its appropriate point on the playing field if the lighting system is to provide both the horizontal and vertical uniformity, and freedom from objectionable glare for which the installation was designed. To facilitate the actual aiming process, an aiming or "spotting" diagram prepared in advance is generally employed (see Fig. A-1).

(b) Calculation methods make it possible to predetermine accurately the footcandle distribution provided by any given aiming pattern. However, because such calculations are long and tedious, it is general practice to base spotting or aiming diagrams for certain sports, such as football which employs a symmetric field, or for minor sports where relatively few floodlights are involved, on scale plots of the floodlight beam spread and the area to be lighted, previous calculations, and practical experience with similar installations.

(c) The procedure is as follows: From an end elevation view, similar to that shown for a football field in Fig. A-1(b), the vertical aiming of the floodlight beam axes can be determined to obtain approximately uniform horizontal illumination across the field together with sufficient "spill," "direct filament," or "beam-edge" light in the space above to provide adequate illumination to a height of approximately 50 feet above the field. In this connection, care must be taken to minimize the amount of light from the upper portion of the floodlight beams falling in the opposite stands. A limited number of point calculations along a line perpendicular to the axis of the pole crossarms, based on a single group of floodlights, can be made without excessive difficulty to check the graphical appraisal of the proper vertical aiming angle. Such calculations will increase the accuracy of the aiming diagram, particularly if more than one row of floodlights from a single pole is required. The plan view of the field makes it possible to plan horizontal aiming of the floodlights to provide approximately uniform horizontal illumination in the longitudinal direction of the field.

(d) It will be noted in Fig. A-1(b) that relatively wide beam floodlights (Type 5) are used because the poles are close to the playing field. It will be noted also that the upper parts of the beams of the two sets of floodlights indicated fall in the opposite stands. However, since these are the wide beam type, the candlepower in the upper portions of the beam (more than 16 degrees from beam center) will be low, and the spill brightness from them will be well within comfortable limits when evaluated with respect to the relatively high brightness of the field itself.

(e) For installations differing appreciably from the standard recommendations or involving a large number of floodlights, it is desirable to obtain an aiming diagram prepared by the manufacturer of the lighting equipment.



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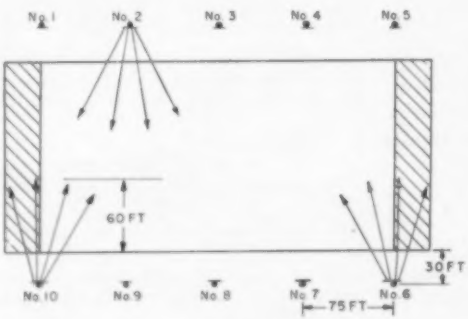

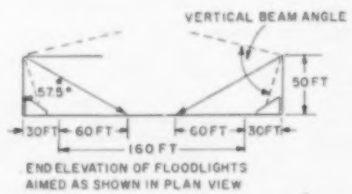

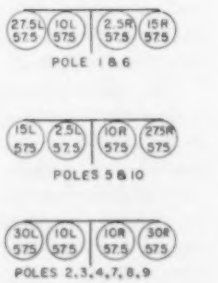
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POLE 1 & 6
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POLES 5 & 10
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10L 57.5
10R 57.5
30R 57.5
POLES 2, 3, 4, 7, 8, 9
30R 50
FIGURE IN TOP OF CIRCLE DENOTES HORIZONTAL DEGREE SETTING, RIGHT OR LEFT, WITH THE OBSERVER BACK OF FLOODLIGHTS FACING IN DIRECTION OF BEAM
FIGURE IN BOTTOM OF CIRCLE DENOTES VERTICAL DEGREE SETTING ABOVE NADIR.

b

Figure A-1. Floodlight spotting diagrams. (a) Manual aiming diagram for a 32-unit softball field for use with a floodlight sight. (b) Angular aiming diagram for a 40-unit football field.

A-2—*Field Methods of Adjusting Floodlights*—(a) There are several ways to put spotting or aiming information to use in making an installation. First, and most accurate, is manual aiming of the floodlight beam centers at predetermined spots on the playing area. This may be accomplished by using built-in beam sights, or by placing accessory beam sights against the floodlights parallel to their optical axes. Then by gridding both the aiming diagram and the playing area into sections, perhaps 30 feet square, markers can be placed at the aiming points on the field designated on the drawing, and the sights aimed at those points.

(b) A second aiming method for directing the floodlights is to calculate or determine graphically from the aiming diagram, the vertical and horizontal angular settings of each floodlight. Most floodlights are equipped with degree scales which may then be set to those angles. The accuracy of this system may be less than that of the one described above unless the poles are set accurately and the crossarms carefully leveled and aligned. A difference of only a few degrees may move the beam center 20 feet more or less, depending upon the mounting height. See Fig. A-2.

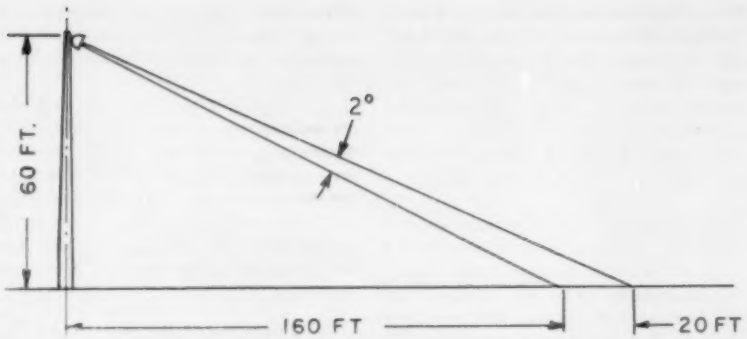

Figure A-2. An error of only a few degrees in angular aiming may move the beam center 20 feet more or less on the playing field.

(c) A third aiming method which may be used successfully with practice is to stand an observer on the field short of the aiming point (so the line from the floodlight to the aiming point passes approximately through the observer's eyes) and observe the floodlight, preferably through binoculars. As the floodlight is moved by an assistant, the observer then estimates the position in which the lamp filament (or concentric reflector rings) appear exactly centered in the floodlight aperture. An alternate observation method that may be used with the narrow-beam (specular reflector) floodlight is to light the lamp and, with smoked glasses on (preferably with binoculars), estimate when the entire reflector appears uniformly bright and at a maximum brightness.

(d) The latter methods are inherently less accurate than the first method but can be satisfactory when relatively large numbers of medium or wide beam floodlights are directed into the same general area.

APPENDIX B—Maintenance.

B-1—*The Importance of Proper Maintenance*—Loss of illumination will result from the use of depreciated lamps and from accumulated dust and dirt on the reflecting or transmitting surface of any luminaire whether installed outdoors or indoors. If the installation is indoors the resultant maintained illumination value is also affected by the condition of the ceiling, walls and general surrounds. Depreciation of 25 to 50 per cent may be expected depending upon the efficiency of the maintenance program (see Fig. B-1).

B-2—*Maintenance Factors for Outdoor Design Calculations*—In the design of a lighting installation calculated to provide specific illumination values using a given quantity of luminaires, it is necessary to assume specific maintenance factors as well as minimum efficiencies. For the basis of lighting design, it is recommended that the NEMA Standards be applied to luminaire designation to permit the use of standard maintenance factors of 75 per cent of initial value for enclosed luminaires and 65 per cent for open luminaires.

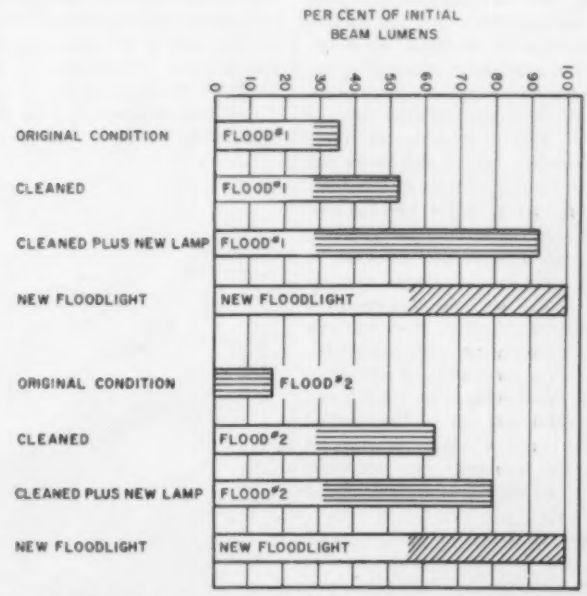

Figure B-1. Necessity for adequate cleaning and relamping program is vividly illustrated by these test results of two floodlights removed from a major league baseball stadium after two seasons of operations.

B-3—*Maintenance Factors for Indoor Design Calculations*—For interior lighting calculations the maintenance factor used will depend upon the design of the specific luminaire chosen. For suggested maintenance factors for typical luminaires refer to Fig. 9-3 of the *IES Lighting Handbook* Third Edition.

B-4—*Frequency of Cleaning* — (a) Since accumulation of foreign matter upon a luminaire depends upon the local atmospheric conditions, it follows that the frequency of cleaning the equipment must be determined on the basis of the existing atmospheric conditions and the type of lighting system employed. It is recommended that floodlight luminaires or industrial type luminaires used out-of-doors be thoroughly cleaned as follows:

(1) At the beginning of each season.

(2) Whenever a lamp is replaced.

(3) In extremely smoky areas at least once and preferably two or three times during the season.

(b) For interior lighting systems a suitable cleaning schedule should be established by a periodic check of the illumination with a light meter. When the illumination has decreased to 75 per cent of its initial value, the equipment should be washed. A thorough washing of interior lighting equipment at least twice a year is justified in most locations. In dirtier areas, three or four cleanings per year are needed to achieve the lowest cost operation in terms of footcandle-hours per dollar.

(c) The frequency of cleaning the surrounds such as walls and ceilings is determined to a large extent by the amount and character of dirt contained in the atmosphere. Regular inspection and adequate cleaning are recommended to maintain the relative efficiency and brightness ratios between luminaires and surrounds.

B-5—*Lamp Replacement* — (a) Replacement of lamps which are badly blackened or considerably depreciated in lumen output is important in maintaining the illumination level for which an installation is designed.

(b) To minimize lamp labor replacement costs and outages during the playing season, a group replacement plan is recommended. Group replacement of all lamps in an installation can be combined effectively with the annual luminaire inspection and cleaning. Because each of the three light sources, incandescent, fluorescent, and mercury, has a different rate of failure over its respective life, the time to group replace is different in each case and is suggested as follows:

	Group Replacement Point
Incandescent	— 85 per cent rated life at operating voltage;
Fluorescent	— 80 per cent rated life;
Mercury	— 100 per cent rated life.

The lamps removed should be visually inspected and the better ones saved for replacement at burnouts prior to the next group replacement. There are, of course, many variables, depending on the type of installation in group replacement, and any particular installation should be gone over thoroughly with lighting engineers to determine the replacement system that will best suit the needs of that installation from both a light and economic standpoint.

B-6—*Cleaning Agents*—Neutral soap or neutral detergents completely dissolved in water, or mild cleaning agents will generally clean lighting equipment satisfactorily. Special cleaners are available for extremely dirty equipment.

B-7—*Physical Inspection*—Every time a luminaire is cleaned or relamped, it should also be inspected for mechanical defects. Prompt correction of any defects will serve to prolong the life of the equipment and minimize frequency of cleaning. Service men should be instructed to exercise reasonable care in handling lighting equipment, especially in not forcing shut the cover-glass doors or globes when incorrectly aligned.

APPENDIX C—Calculation Method for Average Horizontal Footcandles.

C-1—*Introduction*—(a) The method of calculating the footcandle level which can be expected from any given number and arrangement of floodlights or of calculating the number of floodlights required to produce a given level is more complicated than the interior lighting calculation. This is true because there are many variable factors such as the distance from the playing area to the floodlights, the mounting height, and the aiming of the floodlights.

(b) Some approximate methods of calculation have been developed and are available from the manufacturers of lighting equipment. The most accurate method of calculating the footcandles produced by a floodlight installation is one which was developed by NEMA and which is reproduced below. This method involves the use of light distribution curves of the isocandela type on which the area to be lighted is plotted around the beam axis.

(c) For calculation purposes, depending upon the accuracy required, one or more representative floodlight beam patterns should be chosen for each pole location where varying utilizations may result.

(d) The method of computation consists of plotting the area to be lighted on the photometric curve and then adding up the number of lumens contained inside the area. The number of lumens divided by the area in square feet gives the average illumination from the unit in footcandles.

C-2—*Sample Computation* — (a) An example of a typical area to be lighted is given in Fig. C-1. The problem is to obtain the outline of the area in terms of lateral and vertical degrees and transfer it to the isocandela curve (Fig. C-1).

(b) To simplify the problem, the floodlight is assumed to be projecting the

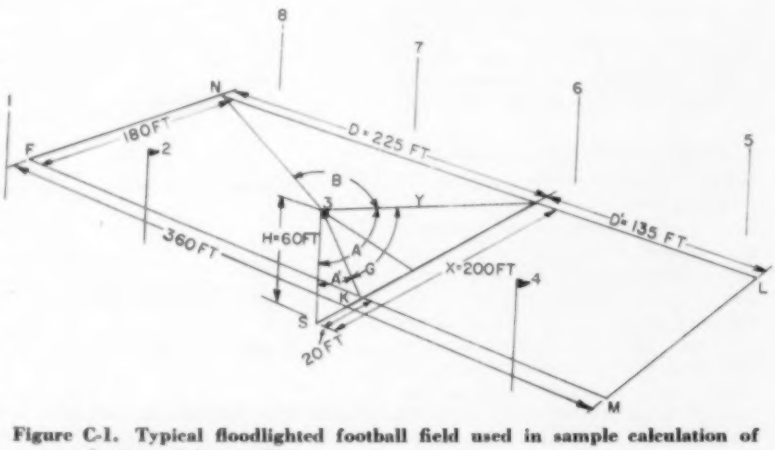

Figure C-1. Typical floodlighted football field used in sample calculation of average horizontal footcandles.

light straight across the area, i.e., a vertical plane through its center axis is perpendicular to the line *FKM* in Fig. C-1. The two sides of the area *NL* and *FM* will appear on the isocandela curve as straight lines parallel to the horizontal beam axis. It is, therefore, necessary to calculate only the vertical angles *A* from the pole to the near and far sides of the area in order to draw them on the diagram. The extremities of these lines, or points *F*, *M*, *L* and *N*, must be found by obtaining the true lateral angle *B* in the plane passing through the floodlight and the side of the field in which the point is located. The contour of the side *FN* or *ML* is found by assuming a number of points on the line and finding the corresponding lateral and vertical angles. The vertical angles (*A*) are found from the nomogram, Fig. C-3. The lateral angles (*B*) are found from Fig. C-4. The exact procedure is as follows:

(1) Refer to Fig. C-3. Lay a straight edge across the chart connecting the distance *X* (200 feet) with the mounting height *H* (60 feet). On the center line *A* read the vertical angle *A* from the pole to the ray of light reaching the far side of the field (73.5 degrees). In the same way using *H* = 60 feet and *X* = 20 feet, the vertical angle (*A'*) to the near side of the field is found to be 18 degrees.

(2) Refer to Fig. C-2. The location of the area on the chart depends on the angle at which the floodlight is tilted. The total vertical angle intercepted by the field is angle *G*, or angle *A* to the far side minus angle *A'* to the near side. This equals 73.5 — 18 or 55.5 degrees. For convenience, assume that the center axis of the floodlight is tilted to the point where it bisects this angle. Then the far side of the field is 55.5 degrees divided by 2 or 27.75 degrees above the axis, and the near side an equal number of degrees below. On the isocandela curve (Fig. C-2) draw horizontal lines 27.75 degrees above and below the 0-degree axis.

(3) To determine point *N*, refer to Fig. C-4. Lay a straight edge across the chart from the mounting height *H* = 60 feet to the vertical angle *A* = 73.5 degrees and read on line *Y* (210 feet). Now connect 210 feet on line *Y* with *D* = 225 feet on line *D*, and read on line *B* the lateral angle (47.5 degrees). Plot this point on the top horizontal line. In the same way, find point *F* by using *A'* = 18 degrees and *D* = 225 feet. Points *L* and *M* are found using the same vertical angles as for *N* and *F*, respectively, and *D'* equals 135 feet.

(4) The four corners of the area are now located, but the ends of the area will not appear as straight lines, so it is necessary to plot sufficient points to determine the curvature. The first points to be determined are those on the 0-degree

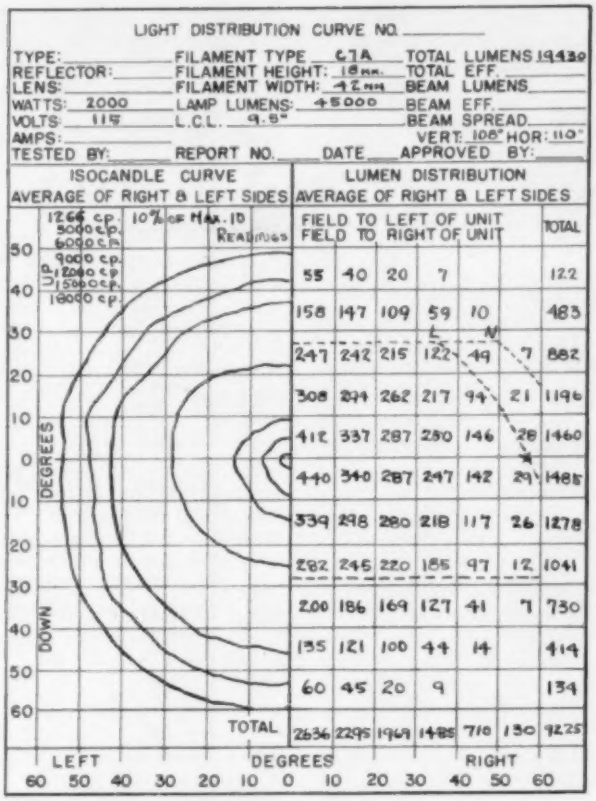

Figure C-2. Floodlight distribution data sheet.

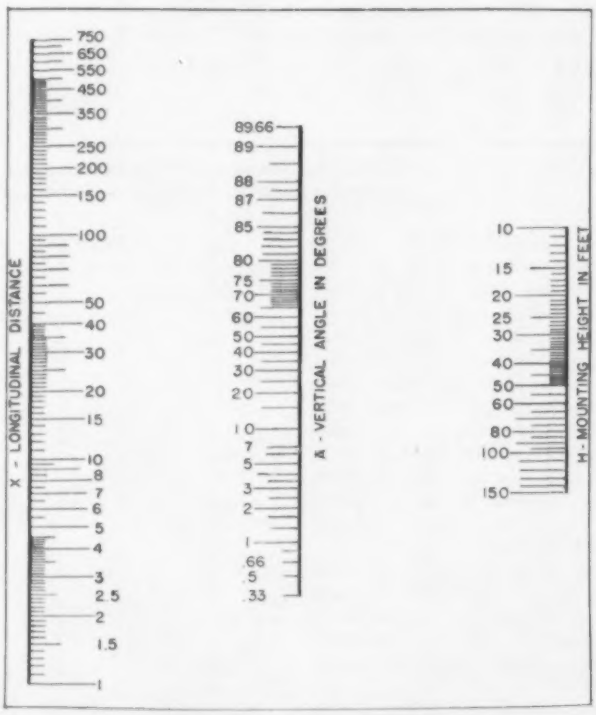

Figure C-3. Nomogram for determining vertical angle (angle *A* in Fig. C-1) in terms of longitudinal distance *X* and mounting height *H*.

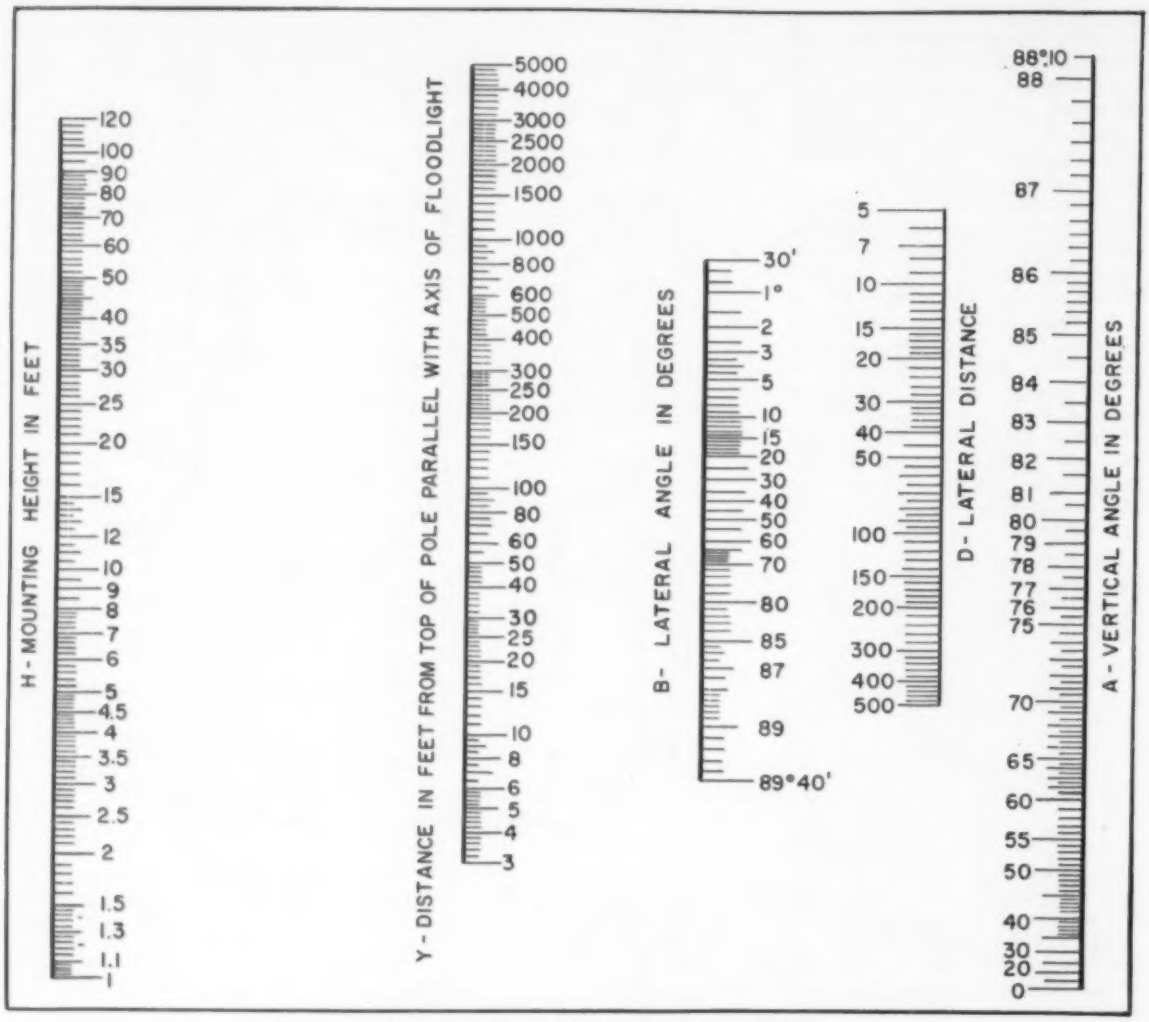

Figure C-4. Nomogram for determining lateral angle *B* in terms of vertical angle *A*, mounting height *H* and distances *Y* and *D*.

center axis. The vertical angle to use on Fig. C-4 is *A* minus 27.75 or 45.75 degrees. From this and $D = 225$ feet the point at the left is found to be 60 degrees, and from $D' = 135$ feet the point at the right is 56 degrees. At least one additional point above the axis and one below should be determined. These may be found by assuming vertical angles such as 15 degrees above the axis, or $A = (45.75 + 15) = 60.75$ degrees. With these points plotted on the isocandela curve the ends of the field can be drawn.

(c) With the field plotted on the curve, the lumens which fall on the field are added up. In the zones cut by the sides of the field estimate the proportion of the lumens included within the boundary. A tabulation of these values is given in Table C-1.

(d) Referring to Fig. C-2, it will be noted that while the calculations have been made for a unit on pole 3, the same

Table C-I—Summation of Lumens on Field.

Vertical Zones	Lateral Zones					
From	0	10	20	30	40	50
To	10	20	30	40	50	60
Field to Right of Unit						
20–30	192	187	167	76	4	
10–20 Above	308	294	262	217	70	
0–10	412	337	287	250	146	10
0–10	440	340	287	247	142	26
10–20 Below	339	298	280	218	117	26
20–30	219	190	171	143	75	9
Field to Left of Unit						
20–30	192	187	167	94	37	1
10–20 Above	308	294	262	217	94	19
0–10	412	337	287	250	146	28
0–10	440	340	287	247	142	29
10–20 Below	339	298	280	218	117	26
20–30	219	190	171	143	75	9
	3820	3292	2908	2320	1165	183

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result applies to any unit on poles 2, 6 and 7. It is then necessary to make a similar calculation for pole 4, for instance, which result will also apply to any unit on poles 1, 5 and 8.

(c) It may happen that a better utilization factor and increased lumens can be obtained by tilting the floodlight at a different vertical angle. This can readily be determined by studying the summation of lumens in the lateral zones, given at the side of the isocandela curve. Tilting the beam up or down merely involves shifting the entire diagram of the field up or down the required number of degrees on the curve.

C-3—*Irregular Areas*—In the case of irregular areas the sides of the field, such as *FM* and *NL*, may not be straight lines or may not be parallel. In that case it will be necessary to determine both the vertical and lateral angles for several points on each line.

C-4—*Special Cases*—(a) In computing values for a closed projector installation where the projectors can be so located that all of the beams will fall on the area involved, the average initial level can be computed by dividing the sum of beam lumens of all of the floodlights by total area. In cases where the entire beam will not fall on the areas involved, the method of computation described in Section C-2 should be used.

(b) For a baseball field installation where the average level for the infield is given, the computations should be made by the method given in Section C-2 or by the point-by-point method, selecting a sufficient number of stations within the area to give a true average. If values are required at specified points, the point-by-point method of computation should be used.

C-5—*Illumination Level at Various Points*—If further details on illumination level at various points are desired, it is recommended that the so-called point-by-point method be used in computing values. In view of the lengthy process and its well-known principle, it is not included in this discussion.

APPENDIX D — Power Supply and Distribution for Floodlighting Installations.

The electric utility serving the sports lighting project should be consulted as to the type and rates for service available, as well as rules for use of this service before plans are developed for the wiring.

In many communities the installation of wiring is governed by local ordinances based on the National Electric Code. In other communities provisions of the Code might well be followed because the merits of the Code are indicated by its widespread acceptance.

Wiring plans will normally be prepared by the electrical engineer, after consultation with the electric utility, giving due consideration to the various factors involved such as service voltage, line voltage drop, and voltage rating of the lamps. These factors should be given consideration in order to secure the most effective use of the complete installation.

APPENDIX E—Guide to Number of Floodlights for Outdoor Sports Calculated on the Basis of NEMA Minimum Efficiencies Required to Produce Recommended Maintained Footcandle Levels as Listed in Table I.

Sport		Layout No.[c]	Number of Floodlights Per Location and Number ( ) of Locations			Total Number Floods	Floodlights			Footcandles Maintained in Service Horizontal[h]	
			A	B	C		Type	Class	Lamp Size		
ARCHERY	Tournament	1	2 (1) 1	1(1)		4	1	GP	1000 G-40[b]	10[v]	
							5	GP	1000 PS-52[b]		
							5	GP	300 PS-35[b]		
	Recreational	1	1 (1) 1	1(1)		3	1	GP	1000 G-40[b]	5[v]	
							5	GP	500 PS-40[b]		
							5	GP	300 PS-35[b]		
BADMINTON	Tournament	2	3(2)			6	5	GP	1500 PS-52[b]	30[h]	
			4(2)			8	6	O	1500 PS-52[b]		
	Club	2	2(2)			4	5	GP	1500 PS-52[b]	20[h]	
			3(2)			6	6	O	1500 PS-52[b]		
	Recreational	2	2(2)			4	5	GP	750 PS-52[b]	10[h]	
			2(2)			4	6	O	1000 PS-52[b]		
BASEBALL Junior League	Class I (base line 60 feet or less)[q]	3	6(2)	12(2)	6(4)	60	3-4-5	GP	1500 PS-52[a]	Infield 40[h]	Outfield 30[h]
			8(2)	16(2)	8(4)	80	4-5-6	OI	1500 PS-52[a]		
	Class II (base line over 60 feet and up to 75 feet)[r]	4	12(2)	24(2)	12(4)	120	3-4-5	GP	1500 PS-52[a]	40[h]	30[h]
			16(2)	32(2)	16(4)	160	4-5-6	OI	1500 PS-52[a]		

All notes will be found at end of Appendix E, page 86.

Appendix E (Continued)

Sport		Layout No.[c]	Number of Floodlights Per Location and Number ( ) of Locations			Total Number Floods	Floodlights		Lamp Size	Footcandles Maintained in Service Horizontal[b]	
			A	B	C		Type	Class			
BASEBALL Regulation	Major League	5	100(2)	200(2)	100(4)	1000	3-4-5	GP	1500 PS-52[a]	150[b]	100[b]
	AAA-AA	5	50(2)	100(2)	50(4)	500	3-4-5	GP	1500 PS-52[a]	75[b]	50[b]
	A-B	5	32(2)	64(2)	32(4)	320	3-4-5	GP	1500 PS-52[a]	50[b]	30[b]
	C-D	5	24(2)	48(2)	24(4)	240	3-4-5	GP	1500 PS-52[a]	30[b]	20[b]
			32(2)	64(2)	32(4)	320	6	OI	1500 PS-52[a]		
	Semi-Pro and Municipal	5	16(2)	32(2)	16(4)	160	3-4-5	GP	1500 PS-52[a]	20[b]	15[b]
			22(2)	44(2)	22(4)	220	6	OI	1500 PS-52[a]		
	Recreational	5	12(2)	24(2)	12(4)	120	3-4-5	GP	1500 PS-52[a]	15[b]	10[b]
			16(2)	32(2)	16(4)	160	6	OI	1500 PS-52[a]		
BASKETBALL	Recreational	6	2(4)			8	5	GP	1500 PS-52[b]	10[b]	
			3(4)			12	6	O	1500 PS-52[b]		
BATHING BEACHES	Water 150 feet out	7	3	every 300 feet		6	3	GP	1500 PS-52[b]	3[e]	
	Beach 100 feet wide		(1) 3				5	GP	1500 PS-52[b]	1[b]	
BOWLING ON THE GREEN	Tournament	8	6(4)	2(4)		32	5	GP	1500 PS-52[b]	10[b]	
			8(4)	4(4)		48	6	O	1500 PS-52[b]		
	Recreational	8	3(4)	1(4)		16	5	GP	1500 PS-52[b]	5[b]	
			4(4)	2(4)		24	6	O	1500 PS-52[b]		
BOXING AND WRESTLING	Championship	9	4(4)			16	3	GP	1500 PS-52[a]	500[b]	
			8(4)			32	4	O	1500 PS-52[a]		
	Professional	9	2(4)			8	4	GP	1500 PS-52[a]	200[b]	
			3(4)			12	4	O	1500 PS-52[a]		
	Amateur	9	2(4)			8	4	GP	1000 PS-52[b]	100[b]	
			2(4)			8	4	O	1500 PS-52[b]		
CASTING	Bait	10	1 (2) 2			6	3	GP	1000 PS-52[b]	Pier 10[b]	Target 5[e,c]
							5	GP	1000 PS-52[b]		
			1 (2) 2			6	3	GP	1000 PS-52[b]		
							6	O	1500 PS-52[b]		
	Dry Fly	11	1 (2) 1			4	3	GP	1000 PS-52[b]	10[b]	5[e,c]
							5	GP	1000 PS-52[b]		
			1 (2) 1			4	3	GP	1000 PS-52[b]		
							6	O	1500 PS-52[b]		
	Wet Fly	12	1 (2) 1			4	3	GP	1000 PS-52[b]	10[b]	5[e,c]
							5	GP	1000 PS-52[b]		
			1 (2) 1			4	3	GP	1000 PS-52[b]		
							6	O	1500 PS-52[b]		
COMBINATION	Baseball and Football	13	16(2)	32(2)	16(4)	160[f]	3-4-5	GP	1500 PS-52[a]	Football 15[b]	
			22(2)	44(2)	22(4)	220[f]	6	OI	1500 PS-52[a]	Infield 20[b]	Outfield 15[b]
COMBINATION	Football	14		14(2)	10(6)	88[f]	3-4-5	GP	1500 PS-52[a]	Football 15[b]	
	Industrial Softball	14	6(2)	14(2)	10(4)	80[f]				Infield 20[b]	Outfield 15[b]
COMBINATION	Six-Man Football	15		10(2)	7(6)	62[f]	5	GP	1500 PS-52[a]	Football 15[f]	
	Industrial Softball	15	6(2)	10(2)	7(6)	74[f]				Infield 20[b]	Outfield 15[b]

All notes will be found at end of Appendix E, page 86.

Appendix E (Continued)

Sport			Layout No.[c]	Number of Floodlights Per Location and Number ( ) of Locations			Total Number Floods	Floodlights		Lamp Size	Footcandles Maintained in Service Horizontal[h]
				A	B	C		Type	Class		
CROQUET	Tournament		16	1 (4) 1			4	5	GP	1000 PS–52[b]	10[h]
								6	O	1500 PS–52[b]	
	Recreational		16	1 (4) 1			4	5	GP	500 PS–40[b]	5[h]
								6	O	730 PS–52[b]	
FOOTBALL Regulation	Class I	Distance to Poles (Feet)									
		over 140	17	90(6)			540	1–2	GP	1500 PS–52[a]	100[h]
		100–140		80(6)			480	2–3	GP	1500 PS–52[a]	
	Class II	75–100	17	36(6)			216	3	GP	1500 PS–52[a]	50[h]
		50–75		24(8)			192	3	GP	1500 PS–52[a]	
	Class III	30–50	17	16(8)			128	4	GP	1500 PS–52[a]	30[h]
	Class IV	15–30	17	8(10)			80	5	GP	1500 PS–52[a]	20[h]
				12(10)			120	6	OI	1500 PS–52[a]	
				18(10)			180	6	O	1500 PS–52[a]	
	Class V	15–30	17	4(10)			40	5	GP	1500 PS–52[a]	10[h]
				6(10)			60	6	OI	1500 PS–52[a]	
				8(10)			80	6	O	1500 PS–52[a]	
FOOTBALL Rugby	Class I	over 140	18	120(6)			720	1–2	GP	1500 PS–52[a]	100[h]
		100–140		106(6)			636	2–3	GP	1500 PS–52[a]	
	Class II	75–100	18	48(6)			288	3	GP	1500 PS–52[a]	50[h]
		50–75		32(8)			256	3	GP	1500 PS–52[a]	
	Class III	30–50	18	21(8)			168	4	GP	1500 PS–52[a]	30[h]
	Class IV	15–30	18	11(10)			110	5	GP	1500 PS–52[a]	20[h]
				16(10)			160	5–6	OI	1500 PS–52[a]	
				24(10)			240	6	O	1500 PS–52[a]	
	Class V	15–30	18	5(10)			50	5	GP	1500 PS–52[a]	10[h]
				8(10)			80	5–6	OI	1500 PS–52[a]	
				11(10)			110	6	O	1500 PS–52[a]	
FOOTBALL Six-Man	College or High School	Distance to Poles (Feet)									
		30–50	19	7(8)			56	5	GP	1500 PS–52[a]	20[h]
		15–30		6(8)			48	5	GP	1500 PS–52[a]	
				9(8)			72	6	OI	1500 PS–52[a]	
				12(8)			96	6	O	1500 PS–52[a]	
	Jr. High School or Recreational	30–50	19	4(8)			32	5	GP	1500 PS–52[a]	10[h]
		15–30		3(8)			24	5	GP	1500 PS–52[a]	
				5(8)			40	6	OI	1500 PS–52[a]	
				6(8)			48	6	O	1500 PS–52[a]	
GOLF	Driving Range		20	3 2(4)[g] 1			24	1 3 5	GP GP GP	1000 G–40[b] 1500 PS–52[b] 1500 PS–52[b]	5[v, i] 10[h, i]
HANDBALL Two-Court	Club		21	2(2)	4(1)		8	5	GP	1000 PS–52[b]	20[h]
				2(2)	4(1)		8	6	O	1500 PS–52[b]	
	Recreational		21	2(2)			4	5	GP	1000 PS–52[b]	10[h]
				2(2)			4	6	O	1500 PS–52[b]	

All notes will be found at end of Appendix E, page 86.

Appendix E (Continued)

Sport			Lay-out No.[c]	Number of Floodlights Per Location and Number ( ) of Locations A	B	C	Total Number Floods	Floodlights Type	Class	Lamp Size	Footcandles Maintained in Service Horizontal[b]
HOCKEY, FIELD (180 Feet x 300 Feet)	College or High School	Distance to Poles (Feet)									
		75–100	22	16(6)			96	3	GP	1500 PS-52[a]	20[b]
		50–75		12(8)			96	3	GP	1500 PS-52[a]	
		30–50		10(8)			80	4	GP	1500 PS-52[a]	
		20–30		8(10)			80	5	GP	1500 PS-52[a]	
		20–30		12(10)			120	6	OI	1500 PS-52[a]	
HOCKEY, ICE (200 Feet x 85 Feet)	Professional		23	10(4)	10(4)		80	5	GP	1500 PS-52[a]	50[b]
				18(4)	18(4)		144	6	O	1500 PS-52[a]	
	Amateur		23	4(4)	4(4)		32	5	GP	1500 PS-52[a]	20[b]
				7(4)	7(4)		56	6	O	1500 PS-52[a]	
	Recreational		23	3(4)	2(4)		20	5	GP	1500 PS-52[b]	10[b]
				5(4)	4(4)		36	6	O	1500 PS-52[b]	
HORSESHOE COURTS	Tournament 4 to 6 Courts		24	1(2)	1(2)		4	5	GP	1500 PS-52[b]	10[b]
				2(2)	2(2)		8	6	O	1000 PS-52[b]	
	Tournament 1 to 3 Courts		24	1(2)			2	5	GP	1500 PS-52[b]	
				2(2)			4	6	O	1000 PS-52[b]	
	Recreational 4 to 6 Courts		24	1(2)	1(2)		4	5	GP	750 PS-52[b]	5[b]
				1(2)	1(2)		4	6	O	1000 PS-52[b]	
	Recreational 1 to 3 Courts		24	1(2)			2	5	GP	750 PS-52[b]	
				1(2)			2	6	O	1000 PS-52[b]	
LACROSSE	College or High School	Distance to Poles (Feet)									
		75–100	25	18(6)			108	3	GP	1500 PS-52[a]	20[b]
		50–75		14(8)			112	4	GP	1500 PS-52[a]	
		30–50		12(8)			96	4	GP	1500 PS-52[a]	
		20–30		10(10)			100	5	GP	1500 PS-52[a]	
		20–30		14(10)			140	5-6	OI	1500 PS-52[a]	
PLAYGROUNDS			26	(2 min.) 20 lamp lumens per sq. ft.				5	GP	500 to 1000[b]	5[b]
				(2 min.) 25 lamp lumens per sq. ft.				6	O or OI	500 to 1000[b]	
PUTTING GREENS			27	(3 min.) 35 lamp lumens per sq. ft.				5	GP	500 to 1500[b]	10[b]
				(3 min.) 50 lamp lumens per sq. ft.				6	O or OI	500 to 1500[b]	
QUOITS	Recreational 4 to 6 Courts		28	1(4)			4	5	GP	750 PS-52[b]	5[b]
				1(4)			4	6	O	1000 PS-52[b]	
	Recreational 1 to 3 Courts		28	1(2)			2	5	GP	750 PS-52[b]	5[b]
				1(2)			2	6	O	1000 PS-52[b]	
RACING Auto Track ¼ Mile	High Mounting		29	22(1)	22(2)	24(4)	162	2	GP	1500 PS-52[a]	20[b]
	Low Mounting		30	8(3)	8(2)	8(13)	144	2-3	GP	1500 PS-52[a]	
RACING Dog Track ¼ Mile	High Mounting		31	7(4)	7(2)	7(14)	140	2-3-5	GP	1500 PS-52[a]	30[b]
	Low Mounting		32	4(5)	9(4)	9(24)	272	2-3-5 6	GP OI or O	1500 PS-52[a] 500 PS-40[a]	
RACING Horse Track 1 Mile	High Mounting		33	24(5)	24(3)	24(19)	648	2-3-5	GP	1500 PS-52[a]	20[b]
	Low Mounting		34	24(5)	18(4)	3(147)	633	2-3-5	GP	1500 PS-52[a]	
				24(5)	18(4)	4(147)	780	6	OI	1500 PS-52[a]	

All notes will be found at end of Appendix E, page 86.

Appendix E (Continued)

Sport			Lay-out No.[c]	Number of Floodlights Per Location and Number ( ) of Locations A	B	C	Total Number Floods	Floodlights Type	Class	Lamp Size	Footcandles Maintained in Service Horizontal[h]
RIFLE RANGE	50 Yards		35	2(2)	2(2)	2(20)	48	5 4	GP GP	1500 PS-52[b] 150 A-23[b]	$10^{b,i}$ $5^{b,i}$ $50^{v,i}$
SHUFFLEBOARD	Tournament 4 to 6 Courts		36	1(2)	1(2)		4	5	GP	1500 PS-52[b]	10^{b}
				2(2)	2(2)		8	6	O	1000 PS-52[b]	
	Tournament 1 to 3 Courts		36	1(2)			2	5	GP	1500 PS-52[b]	
				2(2)			4	6	O	1000 PS-52[b]	
	Recreational 4 to 6 Courts		36	1(2)	1(2)		4	5	GP	750 PS-52[b]	5^{b}
				1(2)	1(2)		4	6	O	1000 PS-52[b]	
	Recreational 1 to 3 Courts		36	1(2)			2	5	GP	750 PS-52[b]	
				1(2)			2	6	O	1000 PS-52[b]	
	Tournament (overhead)		36	1(10)			10[k]			500 PS-40[b]	10^{b}
	Recreational (overhead)		36	1(10)			10[k]			300 PS-35[b]	5^{b}
SKATING	Rink		37	20 lamp lumens per sq. ft.				5	GP	500 to 1500[b]	5^{b}
				25 lamp lumens per sq. ft.				6	O	500 to 1500[b]	
	Pond		37	4 lamp lumens per sq. ft.				5	GP	500 to 1500[b]	1^{b}
				5 lamp lumens per sq. ft.				6	O	500 to 1500[b]	
SKEET			38	4(2)			8	2	GP	1500 PS-52[b]	$30^{v,i}$ $10^{b,n}$
SKI SLOPE			39	2(2) 2(2) 10 Lamp lumens per sq. ft.			3	3-4-5	GP	300 to 1500[b]	3^{b}
SOCCER	Professional and College	Distance to Poles (Feet)									
		over 140	40	30(6)			180	1-2	GP	1500 PS-52[a]	30^{b}
		100-140		28(6)			168	2-3	GP	1500 PS-52[a]	
		75-100		24(6)			144	3	GP	1500 PS-52[a]	
		50-75		16(8)			128	3	GP	1500 PS-52[a]	
	High School	30-50	40	12(8)			96	4	GP	1500 PS-52[a]	20^{b}
				10(10)			100	5	GP		
		15-30		14(10)			140	5-6	OI		
				20(10)			200	6	O		
	Recreational	15-30	40	6(10)			60	5	GP	1500 PS-52[a]	10^{b}
				8(10)			80	6	OI		
				10(10)			100	6	O		
SOFTBALL	Professional & Championship	Outfield Distance (Feet)	41								Infield / Outfield
		280		14(2)	30(2)	18(4)	160	3-4-5	GP	1500 PS-52[a]	50^{b} / 30^{b}
		240		14(2)	20(2)	13(4)	120				
	Semi-Pro	280	41	8(2)	18(2)	14(4)	108	5	GP	1500 PS-52[a]	30^{b} / 20^{b}
				10(2)	28(2)	18(4)	148	6	OI		
		240		8(2)	14(2)	10(4)	84	5	GP		
				10(2)	22(2)	12(4)	112	6	OI		
	Recreational (6-Pole)	200	41	3(2)	4(2)	5(2)	24	5	GP	1500 PS-52[a]	10^{b} / 7.5^{b}
				4(2)	5(2)	6(2)	30	6	OI		
				5(2)	7(2)	8(2)	40	6	O		

All notes will be found at end of Appendix E, page 86.

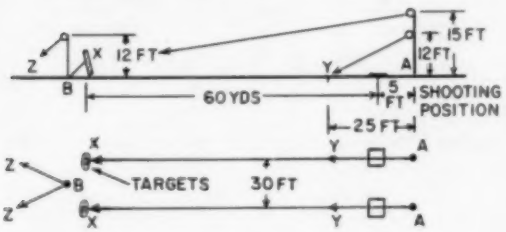
Appendix E (Continued)

Sport			Layout No.[c]	Number of Floodlights Per Location and Number ( ) of Locations A	B	C	Total Number Floods	Floodlights Type	Class	Lamp Size	Footcandles Maintained in Service Horizontal[b]	
SOFTBALL	Industrial League	Outfield Distance (Feet) 280	41	6(2)	14(2)	10(4)	80	5	GP	1500 PS-52[a]	20[b]	15[b]
				8(2)	18(2)	12(4)	100	6	OI			
				10(2)	24(2)	15(4)	128	6	O			
		240		6(2)	10(2)	7(4)	60	5	GP	1500 PS-52[a]		
				8(2)	12(2)	9(4)	76	6	OI			
				10(2)	15(2)	11(4)	94	6	O			
		200		5(2)	7(2)	5(4)	44	5	GP	1500 PS-52[a]		
				7(2)	9(2)	7(4)	60	6	OI			
				9(2)	12(2)	9(4)	78	6	O			
SWIMMING POOL	Overhead Pole-mounted floodlights		42	(4 min.) 35 lamp lumens per sq. ft.				5	GP	500 to 1500[b]	10[b]	
				(4 min.) 50 lamp lumens per sq. ft.				6	O			
	Underwater, Outdoors		42	60 lamp lumens per sq. ft. of pool surface				See Layout 42, page 100.				
	Underwater, Indoors			100 Lamp lumens per sq. ft. of pool surface								
TENNIS (Pole-Mounted Floodlights)	Tournament—Single Court		43	3(4)	2(4)		20	5	GP	1500 PS-52[b]	30[b]	
				4(4)	3(4)		28	6	O			
	Club—Single Court		43	2(4)	1(4)		12	5	GP		20[b]	
				3(4)	2(4)		20	6	O			
	Recreational—Single Court		43	2(4)			8	5	GP	1000 PS-52[b]	10[b]	
				2(4)			8	6	O	1500 PS-52[b]		
	Club—Double Court		44	4(4)	2(4)		24	5	GP	1500 PS-52[b]	20[b]	
				5(4)	3(4)		32	6	O			
	Recreational—Double Court		44	2(4)	1(4)		12	5	GP	1500 PS-52[b]	10[b]	
				3(4)	1(4)		16	6	O			
				3(4)			12	5	GP			
				4(4)			16	6	O			
TENNIS (Incandescent Suspended Luminaires)	Club—Single Court		45	7 Messenger Cable			7	Luminaire deep bowl wide spread reflector		1500 PS-52[b]	20[b]	
	Recreational—Single Court									1000 PS-52[b]	10[b]	
	Tournament—Double Court		45	18 Messenger Cable			18	Deep bowl wide spread reflector		1500 PS-52[a]	30[b]	
	Club—Double Court									1500 PS-52[b]	20[b]	
	Recreational—Double Court									1000 PS-52[b]	10[b]	
TENNIS (Fluorescent Suspended Luminaires)	Recreational—Single Court		46	20 Messenger			20	Wide Spread		1.4–1.5 Amp Fluorescent	10[b]	
	Recreational—Double Court			40 Cable			40					
TRAP SHOOTING			47	4(1)	4(1)		8	2	GP	1500 PS-52[a]	30[r,m]	10[b,n]
VOLLEY BALL	Tournament		48	3(2)			6	5	GP	1500 PS-52[b]	20[b]	
				5(2)			10	6	O	1500 PS-52[b]		
	Recreational		48	2(2)			4	5	GP	1500 PS-52[b]	10[b]	
				3(2)			6	6	O	1500 PS-52[b]		

[a]Lamps operated at 10 per cent over voltage.
[b]Lamps operated at normal voltage.
[c]Layout number refers to drawings, pp. 87-102.
[d]No reference.
[e]Vertical footcandles at 80 feet.
[f]Quantities based on repositioning floodlights.
[g]Minimum of four pole locations should be used for golf driving ranges.
[h]Horizontal footcandles.
[i]Vertical footcandles at 200 yards and 10 horizontal footcandles at tees.
[j]Firing point, 10 footcandles; range, 5 footcandles; targets, 50 footcandles.
[k]Direct luminaires spread distribution.
[m]Thirty footcandles on target at 105 feet.
[n]Ten footcandles at firing point.
[s]Class I Junior League baseball includes Little League, Little Boys League, Khoury League, etc.
[r]Class II Junior League baseball includes Pony League, Bigger League, etc.
[t]Thirty footcandles on target at 60 feet.
[v]Vertical footcandles.

Recommended Layouts for Outdoor Sports

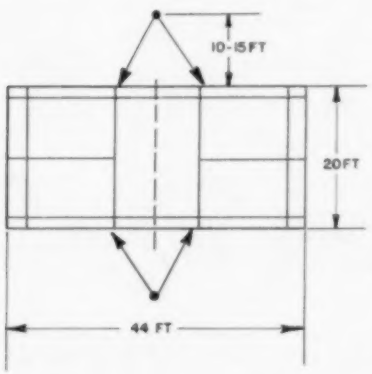
1. Archery—Outdoor Range



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights		
		Aiming Point	Type	Class
Tournament	10	X	1	GP
		Y	5	GP
Recreational	5	Z	5	GP

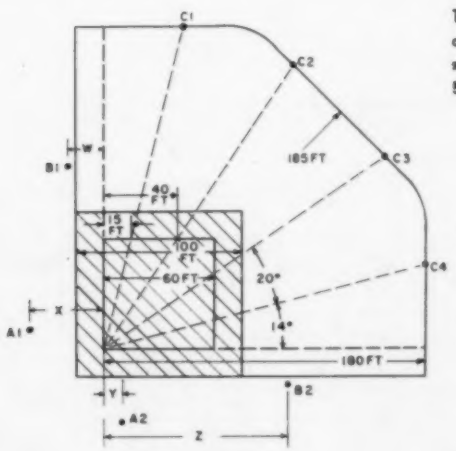
Locate pole B to one side of single target.

2. Badminton—Outdoor Courts



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights		Mounting Height (Feet)
		Type	Class	
Tournament	30	5	GP	20–25
		6	O	
Club	20	5	GP	
		6	O	
Recreational	10	5	GP	
		6	O	

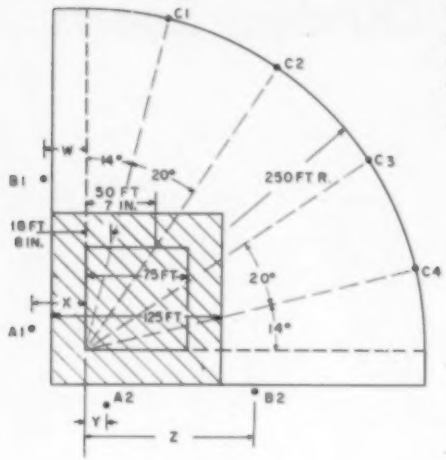
3. Baseball—Class I Junior League (Baselines 60 feet or less)



This layout is based on the following total playing area including a strip 20 feet wide outside each foul line. Infield Area—10,000 square feet. Outfield Area—25,100 square feet (approximately). Dimensions: W = 20 feet to 30 feet; X = 30 feet to 50 feet; Y = 5 feet to 15 feet; Z = 90 feet to 110 feet.

Class of Baseball	IES Current Recommended Practice—Footcandles Maintained in Service		Floodlights		Minimum Mounting Height to Bottom Floodlight Crossarm (Feet)	
	Infield	Outfield	Type	Class	A & B Poles	C Poles
Class I	40	30	3, 4 or 5	GP	40	50
			4, 5 or 6	O or OI		

4. Baseball—Class II Junior League (Baselines longer than 60 feet and up to 75 feet)

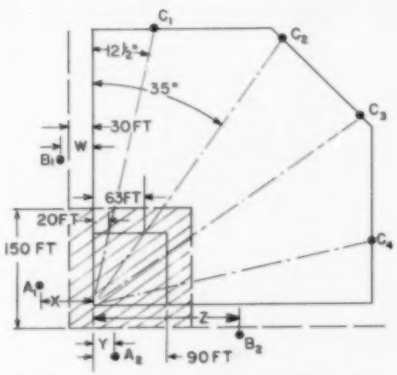


This layout is based on the following total playing area including a strip 25 feet wide outside each foul line: Infield Area—15,625 square feet. Outfield Area—46,600 square feet. Dimensions: W = 25 feet to 45 feet; X = 35 feet to 65 feet; Y = 10 feet to 25 feet; Z = 110 feet to 145 feet.

Class of Baseball	*IES Current Recommended Practice—Footcandles Maintained in Service*		*Floodlights*		*Minimum Mounting Height to Bottom Floodlight Crossarm (Feet)*	
	Infield	*Outfield*	*Type*	*Class*	*A & B Poles*	*C Poles*
Class II	40	30	3, 4 or 5	GP	50	60
			4, 5 or 6	OI		

5. Baseball—Regulation

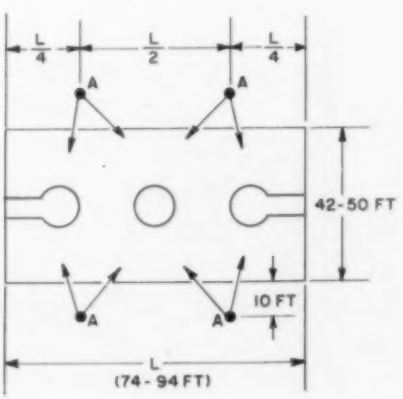
Class of Baseball (Regulation)	*IES Current Recommended Practice—Footcandles Maintained in Service*		*Floodlights*		*Minimum Mounting Height to Bottom Crossarm (Feet)*
	Infield	*Outfield*	*Type*	*Class*	
Major League	150	100	3, 4 or 5	GP	120
AAA or AA	70	50	3, 4 or 5	GP	110
A and B	50	30	3, 4 or 5	GP	90
C and D	30	20	3, 4 or 5	GP	70
Semi-Professional and Municipal	20	15	3, 4 or 5	GP	70
			4, 5 or 6	OI	
Recreational	15	10	3, 4 or 5	GP	70
			4, 5 or 6	OI	



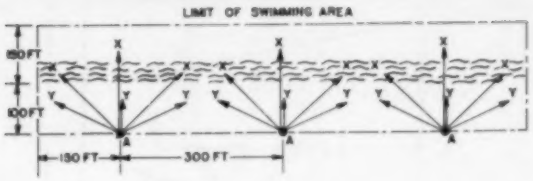
These layouts are based on the following total playing area including a strip 30 feet wide outside each foul line—132,500 square feet. Infield Area (shaded)—22,500 square feet. Outfield Area—110,000 square feet. Dimensions: W = 30 feet to 60 feet; X = 40 feet to 80 feet; Y = 20 feet to 30 feet; Z = 130 feet to 180 feet.

6. Basketball—Outdoor Courts

Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Floodlights*		*Minimum Mounting Height (Feet)*
		Type	*Class*	
Recreational	10	5 or 6	GP or O	30



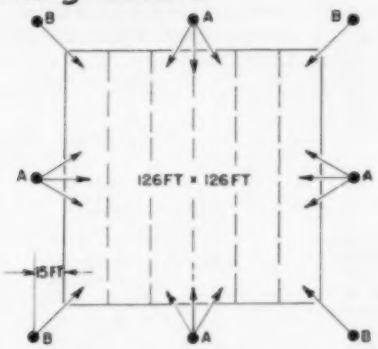
7. Bathing Beaches



IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*		
	Aiming Point	*Type*	*Class*
3 (vertical) in surf at 150 feet	X	3	GP
1 on beach	Y	5	GP

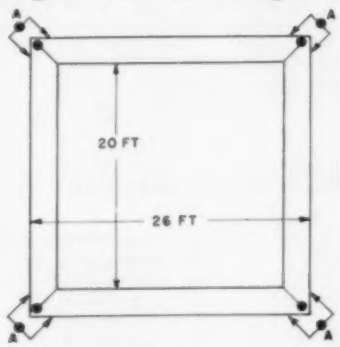
Mounting Height: 60 feet above beach.

8. Bowling Greens



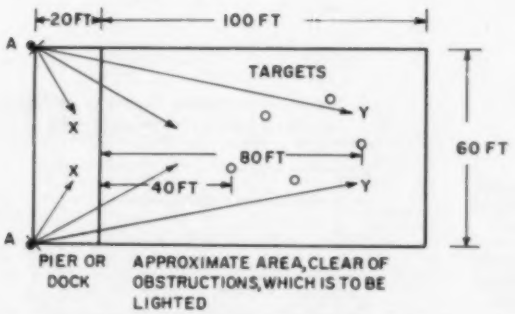
Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Floodlights*		*Minimum Mounting Height (Feet)*
		Type	*Class*	
Tournament	10	5	GP	25
		6	O	
Recreational	5	5	GP	
		6	O	

9. Boxing—Outdoor Rings



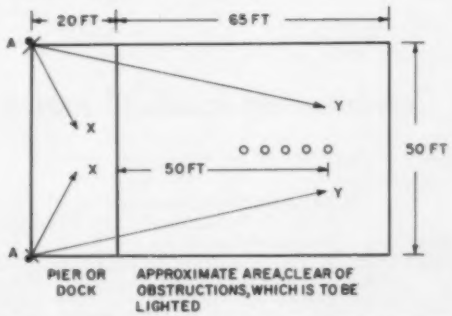
Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Floodlights*		*Mounting Height (Feet)*
		Type	*Class*	
Championship	500	3 or 4	GP O	15–20
Professional	200	4 or 4	GP O	
Amateur	100	4 or 4	GP O	

10. Casting—Bait



IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*			*Mounting Height (Feet)*
	Letter Designation	*Type*	*Class*	
General on pier or dock—10	X	5 or 6	GP O	25
On vertical surface at 80 feet—5	Y	3	GP	25

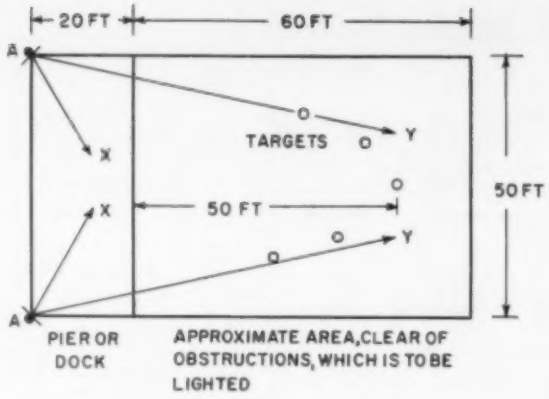
11. Casting—Wet Fly



IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*			*Mounting Height (Feet)*
	Letter Designation	*Type*	*Class*	
General on pier or dock—10	X	5 or 6	GP O	25
On vertical surface at 50 feet—5	Y	3	GP	25

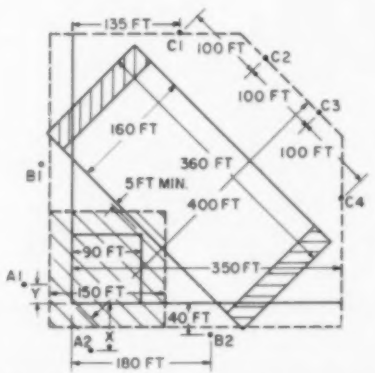
12. Casting–Dry Fly

IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights			Mounting Height (Feet)
	Letter Designation	Type	Class	
General on pier or dock—10	X	5 or 6	GP O	25
On vertical surface at 50 feet—5	Y	3	GP	25



13. Combination Baseball and Football

Sport (Class)	IES Current Recommended Practice—Footcandles Maintained in Service		Floodlights		Minimum Mounting Height to Bottom Floodlight Crossarm (Feet)	
	Infield	Outfield	Type	Class	Poles A1, A2, B1, B2 C1 & C4	Poles C2 & C3
Baseball (Semi-Professional and Municipal)	20	15	3, 4 or 5	GP	70	90
Football	15		4, 5 or 6	OI		

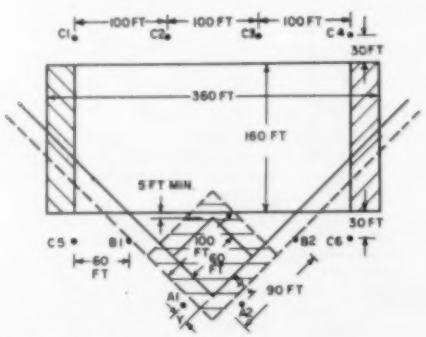


The combination layout is not as satisfactory for either sport as individual layouts. Re-aiming for each sport will increase the effectiveness.

The layouts are based on the following: Total playing area, including a strip 30 feet outside each foul line—132,500 square feet. Infield Area (baseball)—22,500 square feet. Outfield Area—110,000 square feet. Dimensions: X = 40 feet to 80 feet; Y = 20 feet to 30 feet.

14. Combination Football and Softball

Sport (Class)	IES Current Recommended Practice—Footcandles Maintained in Service		Floodlights		Minimum Mounting Height to Bottom Floodlight Crossarm (Feet)
	Infield	Outfield	Type	Class	
Softball (Industrial)	20	15	3, 4 or 5 4, 5 or 6	GP OI	50
Football	15				



The combination layout is not as satisfactory for either sport as individual layouts. Re-aiming for each sport will increase the effectiveness.

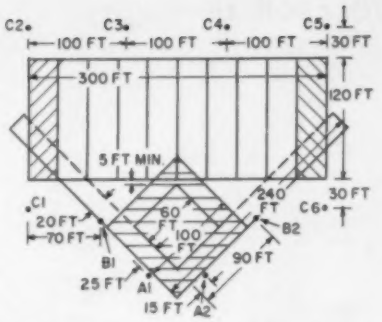
Use all floodlights on all poles except poles C5 and C6 for softball and floodlights on B and C only for football.

The layout is based on the following: Total playing area for softball including a strip 20 feet outside each foul line—85,700 square feet. Infield Area (softball)—10,000 square feet. Outfield Area—75,700 square feet. Dimensions: X = 25 feet to 50 feet; Y = 5 feet to 15 feet.

15. Combination 6-Man Football and Softball

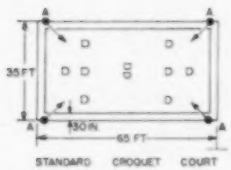
Sport (Class)	IES Current Recommended Practice—Footcandles Maintained in Service		Floodlights		Poles		
	Infield	Outfield	Type	Class	Locations	No.	Mounting Height (Feet)
Softball (Industrial)	20	15	5 4	GP OI	A, B & C	10	50
Football (6-Man)	15		5 4	GP OI	B & C	8	50

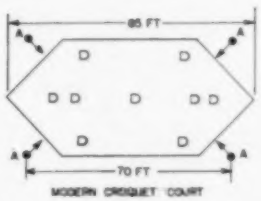
NOTE: "A" poles used only for softball.



The combination layout is not as satisfactory for either sport as individual layouts. Re-aiming for each sport will increase the effectiveness.

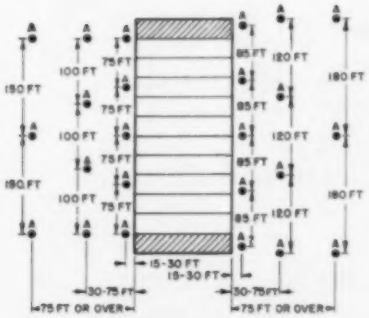
16. Croquet Courts





Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights		Mounting Height (Feet)
		Type	Class	
Tournament	10	5 or 6	GP O	20–25
Recreational	5	5 or 6	GP O	

17. Football—Regulation



Any of the above six pole plans or any intermediate longitudinal spacings are considered good practice with local field conditions dictating exact pole locations.

CLASSIFICATION

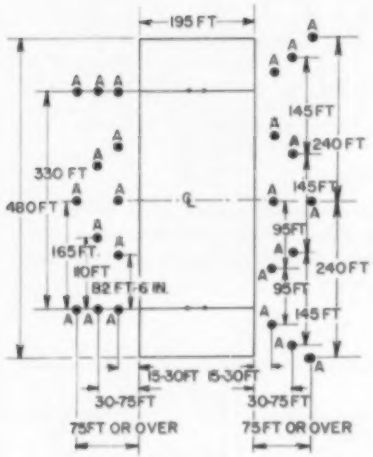
It is generally conceded that distance between the spectators and the play is the first consideration in determining the class and lighting requirements. However, the potential seating capacity of the stands should also be considered.

Class	Distance—Nearest Sideline to Farthest Row of Spectators (Feet)	Spectator Seating Capacity
I	over 100	Over 30,000 spectators
II	50–100	10,000–30,000
III	30–50	5,000–10,000
IV	Under 30	5,000
V	No fixed seating facilities	

Class	IES Current Recommended Practice—Footcandles Maintained in Service	Distance—Nearest Sideline to Floodlight Poles (Feet)	No. of Poles	Floodlights	
				Type	Class
I	100	Over 140 100–140	6 6	1 or 2 2 or 3	GP GP
II	50	75–100 50–75	6 8	3 3	GP GP
III	30	30–50	8	4	GP
IV	20	15–30 15–30 15–30	10 10 10	5 6 6	GP OI O
V	10	15–30 15–30 15–30	10 10 10	5 6 6	GP OI O

For minimum mounting height see chart, page 102.

18. Football—Rugby



Any of the above six pole plans or any intermediate longitudinal spacings are considered good practice with local field conditions dictating exact pole locations.

CLASSIFICATION

It is generally conceded that distance between the spectators and the play is the first consideration in determining the class and lighting requirements. However, the potential seating capacity of the stands should also be considered.

Class	*Distance—Nearest Sideline to Farthest Row of Spectators (Feet)*	*Spectator Seating Capacity*
I	over 100	Over 30,000 spectators
II	50–100	10,000–30,000
III	30–50	5,000–10,000
IV	Under 30	5,000
V	No fixed seating facilities	

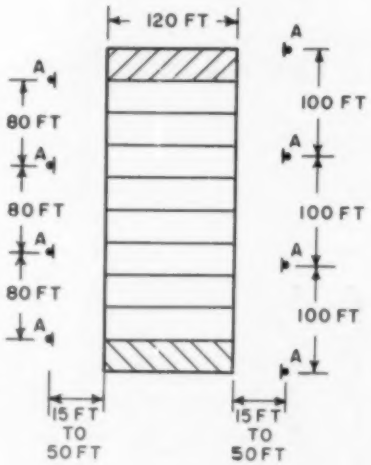
Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Distance—Nearest Sideline to Floodlight Poles (Feet)*	*No. of Poles*	*Floodlights*	
				Type	*Class*
I	100	over 140	6	1 or 2	GP
		100–140	6	2 or 3	GP
II	50	75–100	6	3	GP
		50–75	8	3	GP
III	30	30–50	8	4	GP
IV	20	15–30	10	5	GP
		15–30	10	5 or 6	OI
		15–30	10	6	O
V	10	15–30	10	5	GP
		15–30	10	5 or 6	OI
		15–30	10	6	O

For minimum mounting height see chart, page 102.

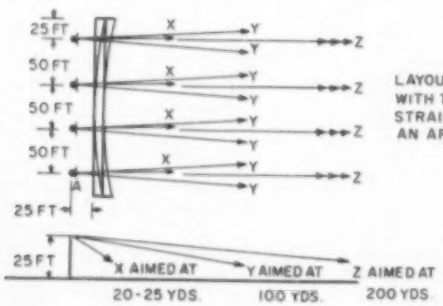
19. Football—6-Man

Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Distance Nearest Sideline to Floodlight Poles (Feet)*	*No. of Poles*	*Floodlights*	
				Type	*Class*
High School or College	20	15–30	8	5 or 6	GP or OI
		30–50	8	5	GP
Jr. High School or Recreation	10	15–30	8	5 or 6	GP or OI
		30–50	8	5	GP

Either of the pole plans at right or any intermediate longitudinal spacing are considered good practice with local field conditions dictating exact pole locations.



20. Golf—Driving Range

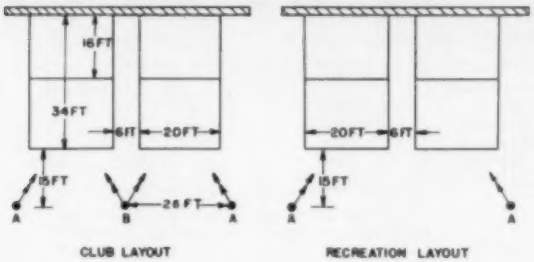


LAYOUT MAY BE USED WITH THE TEES IN A STRAIGHT LINE OR AN ARC.

IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*		
	Aiming Point	*Type*	*Class*
10—general on tees	X	5	GP
	Y	3	GP
5—on vertical surface at 200 yards	Z	1	GP

Minimum mounting height: 25 feet above tees.

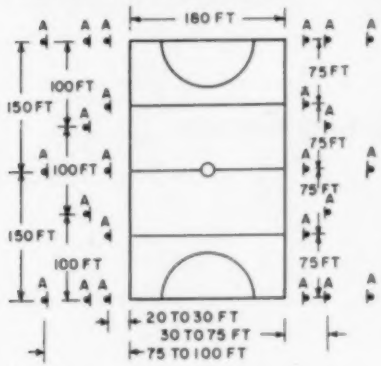
21. Handball—Outdoor Courts



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights	
		Type	Class
Club	20	5 or 6	GP O
Recreational	10	5 or 6	GP O

Minimum mounting height: 25 feet.

22. Hockey—Field



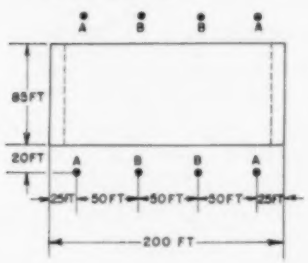
CLASSIFICATION

It is generally conceded that the distance between the spectators and the play is the first consideration in determining the class and lighting requirements. However, the potential seating capacity of the stands should also be considered.

Class	IES Current Recommended Practice—Footcandles Maintained in Service	Distance Nearest Sideline to Floodlight Pole (Feet)	No. of Poles	Floodlights	
				Type	Class
High School or College	20	75–100	6	3	GP
		30–75	8	4	GP
		20–30	10	4, 5 or 6	GP or OI

Any of the 6 pole plans or any intermediate longitudinal spacing are considered good practice with local field conditions dictating the exact locations.
For minimum mounting height see chart, page 102.

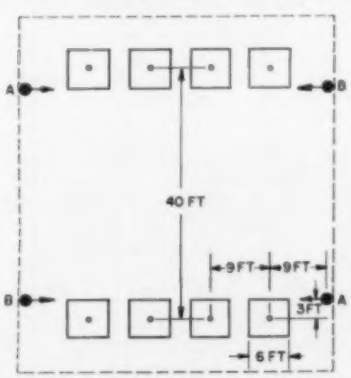
23. Hockey—Outdoor Ice Rinks



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights		Mounting Height (Feet)
		Type	Class	
Professional	50	5	GP	50
		6	OI	
Amateur	20	5	GP	
		6	O	
Recreational	10	5	GP	
		6	O	

Poles: 8

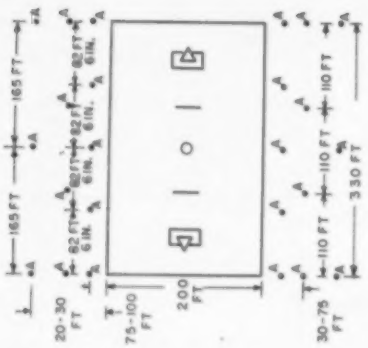
24. Horseshoe Courts



Class	IES Current Recommended Practice—Footcandles Maintained in Service	No. of Courts	Floodlights		Minimum Mounting Height (Feet)
			Type	Class	
Tournament	10	4–6	5 or 6	GP O	20
		1–3	5 or 6	GP O	20
Recreational	5	4–6	5 or 6	GP O	20
		1–3	5 or 6	GP O	20

For 1–3 courts no "B" poles are required.
Poles: 4 for 4–6 court layout, 2 for 1–3 court layout.

25. Lacrosse



CLASSIFICATION

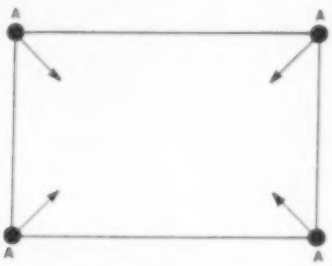
It is generally conceded that the distance between the spectators and the play is the first consideration in determining the class and lighting requirements. However, the potential seating capacity of the stands should also be considered.

Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Distance—Nearest Sideline to Floodlight Pole (Feet)*	*No. of Poles*	*Floodlights*	
				Type	*Class*
High School or College	20	75–100	6	3	GP
		30– 75	8	4	GP
		20–30	10	4, 5 or 6	GP or OI

Any of the 6 pole plans or any intermediate longitudinal spacing are considered good practice with local field conditions dictating the exact locations.

For minimum mounting height see chart, page 102.

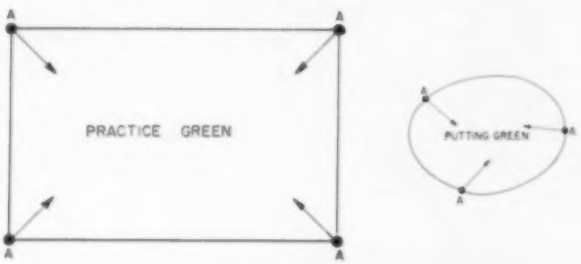
26. Playgrounds



Pole spacing not to exceed 4 times mounting height.

IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*		*Minimum Mounting Height (Feet)*
	Type	*Class*	
5	5	GP	20
	6	O	

27. Practice Putting Greens



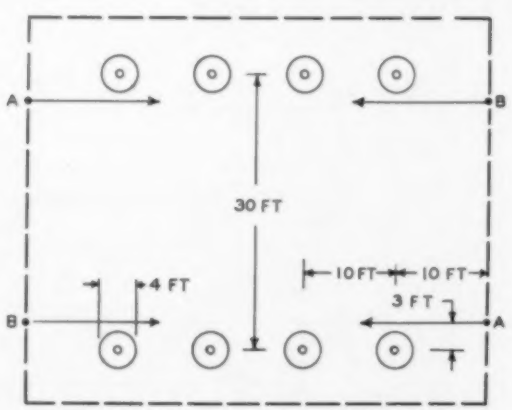
Pole spacing not to exceed 2 times mounting height.

IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*		*Minimum Mounting Height (Feet)*
	Type	*Class*	
10	5	GP	20
	6	O	

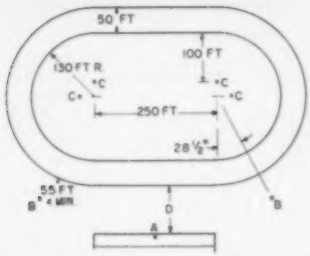
28. Quoits

Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Number of Courts*	*Floodlights*	
			Type	*Class*
Recreational	5	4 to 6	5	GP
			6	O
		1 to 3	5	GP
			6	O

"B" poles are not required for three courts or less.
Mounting height: At least 20 feet above courts.



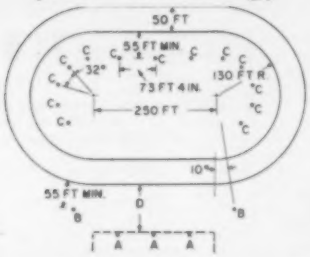
29. Racing—¼-Mile Auto Track (High Mounting)



Variation in quantity and type of floodlights as well as mounting height may be required under conditions which are different from those shown on the recommended layout.
Special consideration should be given to the lighting of the finish line. Floodlights may be mounted on grandstand roof if desired. "Type" specifications and mounting height depend upon floodlight location setback "D".

IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*		*Pole Locations*	*Minimum Mounting Height (Feet)*
	Type	*Class*		
20	2 or 3	GP	A	See Chart, page 102
	2 or 3	GP	B	40
	2	GP	C	65

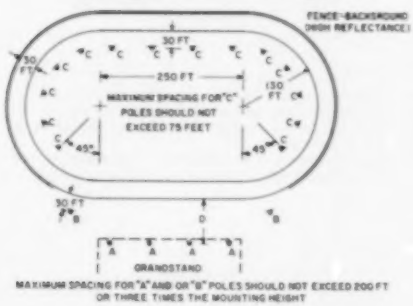
30. Racing—¼-Mile Auto Track (Low Mounting)



Variation in quantity and type of floodlights as well as mounting height may be required under conditions which are different from those shown on the recommended layout.
Special consideration should be given to the lighting of the finish line. Floodlights may be mounted on grandstand roof if desired. "Type" specification and mounting height depend upon floodlight location setback "D".

IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*		*Pole Locations*	*Minimum Mounting Height (Feet)*
	Type	*Class*		
20	2 or 3	GP	A	See Chart, page 102
			B	40
			C	40

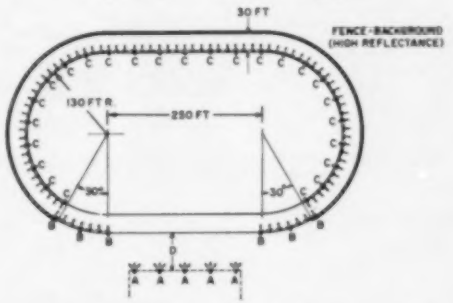
31. Racing—¼-Mile Dog Track (High Mounting)



Variations in quantity and type of floodlights as well as mounting heights may be required under different conditions from those shown in the above layout.
Special consideration should be given to the lighting of the finish line. Floodlights may be mounted on grandstand roof if desired. "Type" specification and mounting height depend upon floodlight location setback "D."

IES Current Recommended Practice—Footcandles Maintained in Service	*Position Designation*	*Floodlight*		*Minimum Mounting Height to Bottom Floodlight Crossarm (Feet)*
		Type	*Class*	
30	A	2 or 3	GP	See Chart, page 102
	B	5	GP	35
	C	5	GP	35

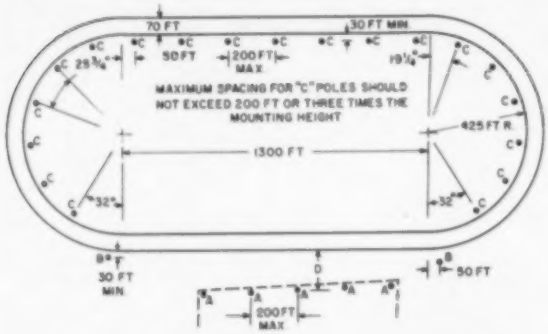
32. Racing—¼-Mile Dog Track (Low Mounting)



This recommendation is based upon the average track width of 30 feet. The same principles apply for different widths, but the total number of lumens should be adjusted in proportion to the total area.
Poles inside and outside track are shown schematically; symbols do not in any way indicate the correct number of poles or lighting units. Units may be supported by messenger cables strung between poles or brackets.
Variations in quantity and type of luminaires as well as mounting heights may be required under conditions different from those shown in the layout.
Special consideration should be given to the lighting of the finish line. Floodlights may be mounted on grandstand roof if desired. "Type" specification and mounting height depend upon floodlight location setback "D."

IES Current Recommended Practice—Footcandles Maintained in Service	*Position Designation*	*Floodlights*		*Mounting Height (Feet)*
		Type	*Class*	
30	A	2, 3, 4 or 5	GP	See Chart, page 102
	B	5	GP	
	C	5 or 6	O or OI	20

33. Racing—One-Mile Horse Track (High Mounting)

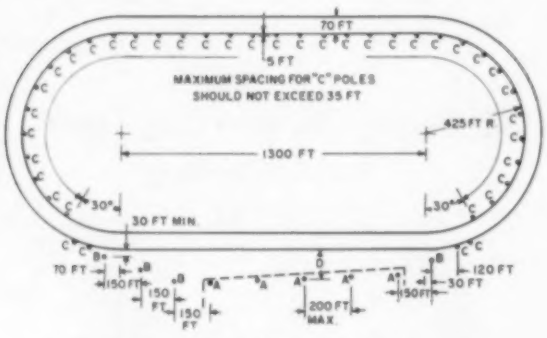


MAXIMUM SPACING FOR "A" AND OR "B" POLES SHOULD NOT EXCEED 200 FT OR THREE TIMES THE MOUNTING HEIGHT

IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*		*Minimum Mounting Height (Feet)*	*Position Designation*
	Type	*Class*		
20	2, 3 or 5	GP	See Chart, page 102	A
	2, 3 or 5	GP	60	B
	3 or 5	GP	60	C

Variations in quantity and type of floodlights as well as mounting heights may be required under conditions different from those shown in the above layout. Special consideration should be given to the lighting of finish line. Floodlights may be mounted on grandstand roof if desired. "Type" specification and mounting height depend upon floodlight location setback "D"

34. Racing—One-Mile Horse Track (Low Mounting)



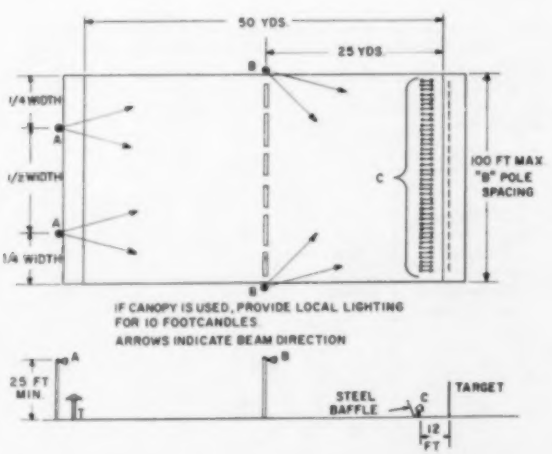
MAXIMUM SPACING FOR "A" AND OR "B" POLES SHOULD NOT EXCEED 200 FT OR THREE TIMES THE MOUNTING HEIGHT

IES Current Recommended Practice—Footcandles Maintained in Service	*Position Designation*	*Floodlights*		*Minimum Mounting Height (Feet)*
		Type	*Class*	
20	A	2, 3 or 5	GP	See Chart, page 102
	B	2, 3 or 5	GP	
	C	4, 5 or 6	OI	30

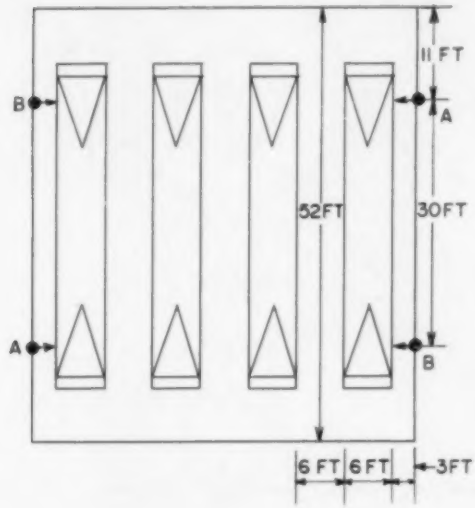
Variations may be required in the type of floodlight at the "A" and "B" locations, as well as the mounting height under conditions different from those shown in the layout. Special consideration should be given to the lighting of the finish line.
Floodlights may be mounted on grandstand roof if desired. "Type" specification and mounting height depend upon floodlight location setback "D."

35. Rifle and Pistol—50-Yard Outdoor Range

IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*			*Mounting Height (Feet)*
	Position Designation	*Average Type*	*Class*	
10 at firing point	A	5	GP	25
5 on range	B	5	GP	25
50 on target	C	4	GP	on ground



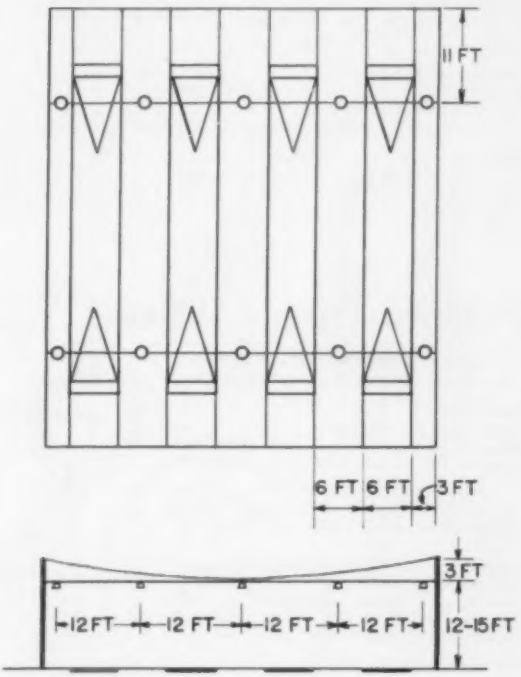
36A. Shuffleboard—Outdoor Courts Using Floodlights



Class	IES Current Recommended Practice—Footcandles Maintained in Service	No. of Courts	Floodlights	
			Type	Class
Tournament	10	4–6	5 or 6	GP O
		1–3	5 or 6	GP O
Recreational	5	4–6	5 or 6	GP O
		1–3	5 or 6	GP O

Note: For 1–3 courts no "B" poles are required.
Mounting height: At least 20 feet above courts.
Poles: Four for 4–6 court layout, two for 1–3 court layout.

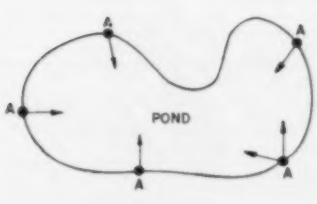
36B. Shuffleboard—Outdoor Courts Using Indoor Type Lighting Units (Adapted for Outdoor Use)



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Luminaire Designation
Tournament	10	Direct (spread distribution)
Recreational	5	Direct (spread distribution)

Mounting Height: As shown.

37. Skating—Outdoor Rink and Pond



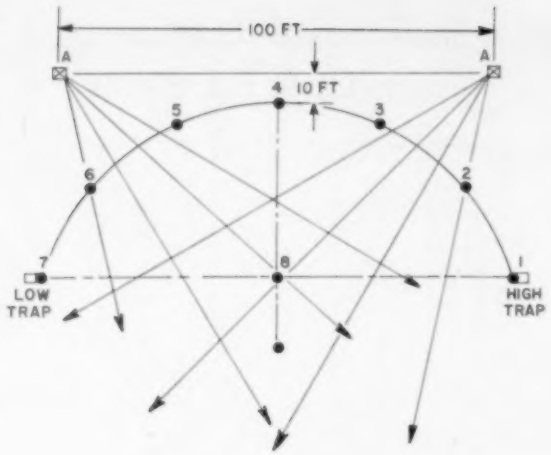
	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights	
		Type	Class
Rinks	5	5	GP
		6	O
Ponds	1	5	GP
		6	O

Pole Spacing: Not to exceed 4 times mounting height.
For minimum mounting height see chart, page 102.

38. Skeet Shooting

IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*		*Minimum Mounting Height (Feet)*
	Type	*Class*	
Target (vertical surface at 60 feet)—30 Firing Point (general)—10	2	GP	25

Poles: 2



39. Skiing, Practice Slopes

IES Current Recommended Practice

Footcandles maintained in service—3.0

Floodlights

DESCRIPTION: Floodlights marked "X" — Type 3, 4 or 5, class GP. Floodlights marked "Y"—Type 3, 4 or 5, class GP.

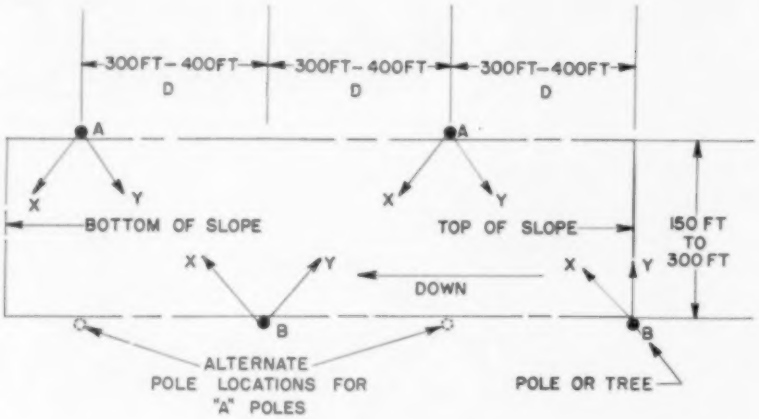
NUMBER: Provide single floodlights or banks of floodlights according to area to be lighted, based on 10 lamp lumens per square foot of area.

DISTRIBUTION: Distribute floodlights to project approximately in ratio of 40 lumens in direction of travel (designated by "X" arrows) and 20 lumens opposing direction of travel ("Y" arrows).

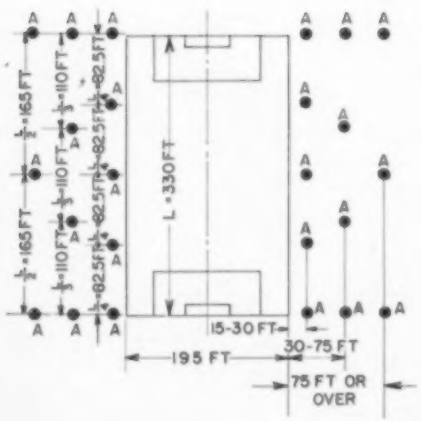
Mounting Height

Not less than 1/10 dimension "D."

NOTES: The above layout is intended for slopes which are free from obstructions. Uphill floodlights are not to be over 500 watts each and with stippled or elliptical spread cover glass.



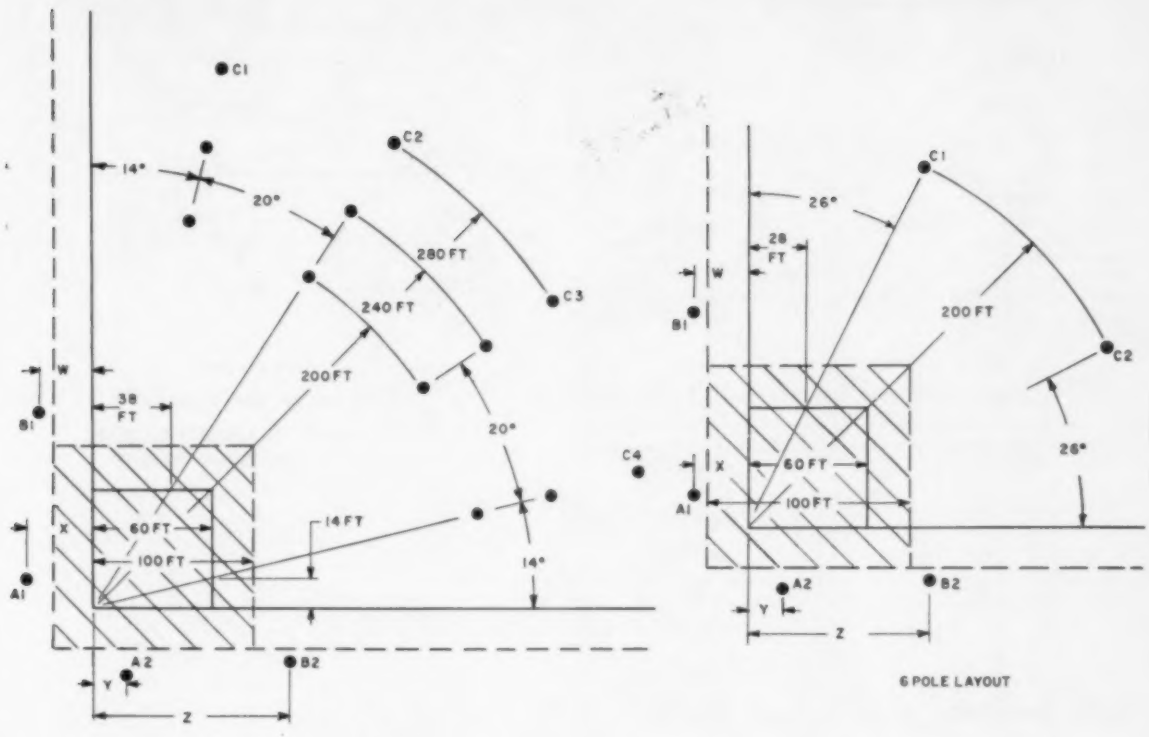
40. Soccer



Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Distance—Nearest Sideline to Floodlight Poles (Feet)*	*No. of Poles*	*Floodlights*	
				Type	*Class*
Professional and College	30	over 140	6	1 or 2	GP
		100–140	6	2 or 3	GP
		75–100	6	3	GP
		50–75	8	3	GP
High School	20	30–50	8	4	GP
		15–30	10	5	GP
		15–30	10	5 or 6	OI
		15–30	10	6	O
Recreational	10	15–30	10	5	GP
		15–30	10	5 or 6	OI
		15–30	10	6	O

For minimum mounting height see chart, page 102.

41. Softball



These layouts are based on the following total playing area including a strip 20 feet wide outside each foul line: Infield Area—10,000 square feet; Outfield Area (200 feet)—29,815 square feet; Outfield Area (240 feet)—45,240 square feet; Outfield Area (280 feet)—70,330 square feet. Dimensions: W = 20 feet to 30 feet; X = 25 feet to 50 feet; Y = 5 feet to 15 feet; Z = 90 feet to 110 feet.

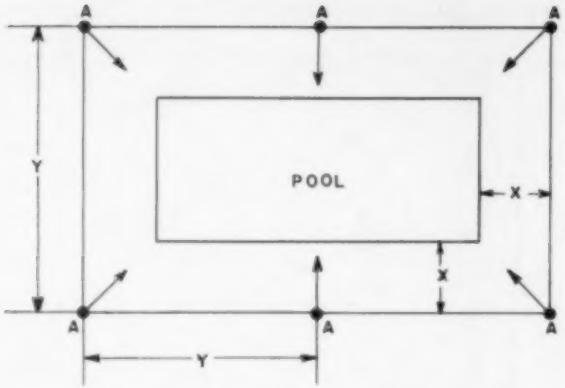
Class	*Outfield (Feet)*	*IES Current Recommended Practice—Footcandles Maintained in Service*		*Floodlights*		*Minimum Mounting Height to Bottom Floodlight Crossarm (Feet)*	
		Infield	*Outfield*	*Type*	*Class*	*A & B Poles*	*C & D Poles*
8-Pole Layout							
Professional and Championship	280 240	50	30	3, 4 or 5	GP	50	60
Semi-Professional	280 240	30	20	3, 4 or 5 4, 5 or 6	GP OI	40 40	55 50
Industrial League	280 240 200	20	15	3, 4, or 5 4, 5 or 6 6	GP OI O	35 35 35	50 45 40
6-Pole Layout							
Recreational	200	10	7	3, 4 or 5 4, 5 or 6 6	GP OI O	35	40

Poles: 6 for recreational; 8 for other classes.
NOTE: Supplementary corner poles may be installed to carry overhead wire around boundary rather than across playing area.

42A. Swimming—Outdoor Pools
Overhead Lighting

IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*		*Lamp Lumens Per Sq. Ft. of Area*	*Minimum Mounting Height (Feet)*
	Type	*Class*		
10	5	GP	35	20
	6	O	50	

The pole locations outline the area to be lighted. Pole spacing not to exceed 4 times mounting height.



DIMENSIONS

X – 20 FT OR MORE

Y – NOT TO EXCEED 4 TIMES MOUNTING HEIGHT

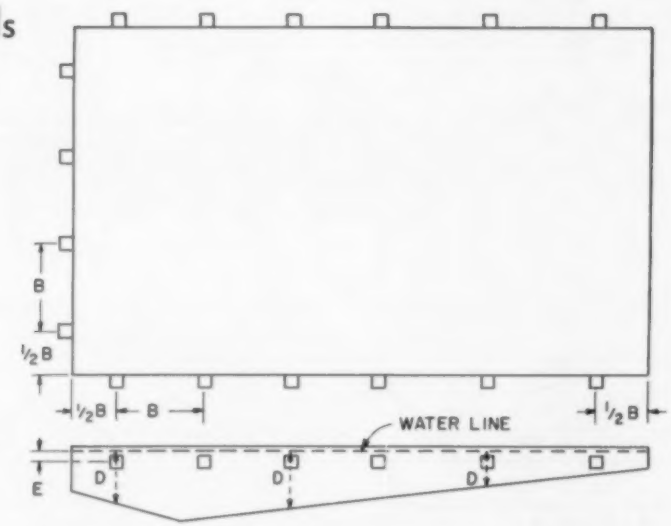
42B. Swimming—Outdoor Pools
Underwater Lighting

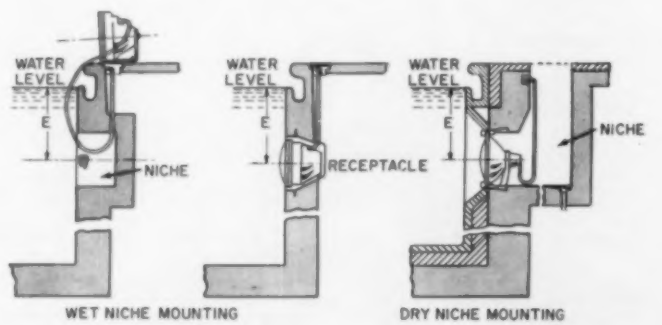
Location of Pool	*Lamp Lumens Per Sq. Ft. of Pool Surface (Width × Length)*
Outdoors	60
Indoors	100

Dimensions

Lamp Lumens	*B Max. (Feet) (Where D is Over 5 Feet)*	*B' Max. (Feet) (Where D is Less than 5 Feet)*	*E (Inches Below Water Line)*	
			Min.	*Max.*
3750 to 8000	8	10	12	15
9900 to 33000	12	15	18	24

Above lighting used specially designed floodlights not covered by I.E.S. Classification or Type. Two systems are used—wet niche and dry niche. The former uses submersible units, while in the latter the casings or niche linings are cast in the pool walls with the floodlights behind them. Use minimum number of floodlights that will satisfy distribution and lumens per square foot.

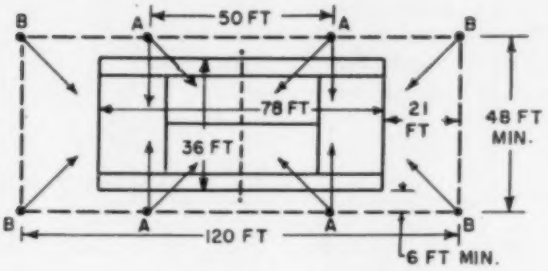




WET NICHE MOUNTING

DRY NICHE MOUNTING

43. Tennis, Single Courts–Floodlighted

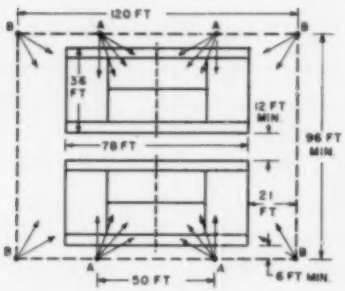


Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights	
		Type	Class
Tournament	30	5 6	GP O
Club	20	5 6	GP O
Recreational*	10	5 6	GP O

Minimum mounting height: 30 feet above court.

* For Recreational play only 4 poles may be used (A locations). These should be spaced 60 feet apart instead of 50 feet.

44. Tennis, Double Court –Floodlighted

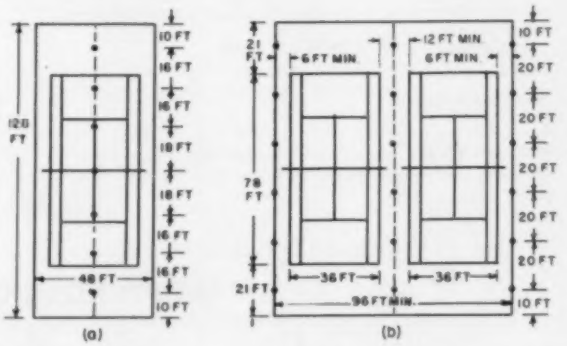


Minimum mounting height: 30 feet above courts.

Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights		
		Pole Locations	Type	Class
Club	20	A&B	5 6	GP O
Recreational	10	A* or A&B	5 6	GP O

* Poles spaced 60 feet apart instead of 50.

45. Tennis–Overhead Incandescent



Mounting height: 30 to 35 feet above court suspended on messenger cable.

Illustrations show two possible arrangements but do not cover all of the possibilities with incandescent luminaires.

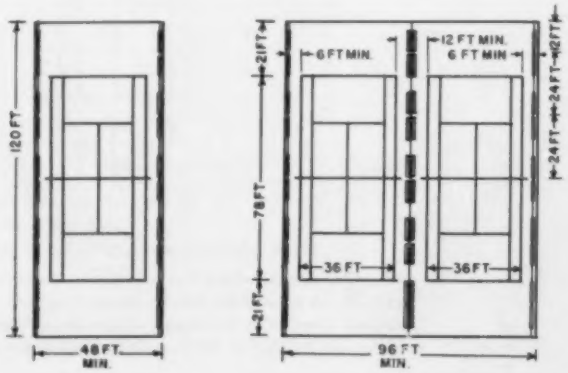
Class	IES Current Recommended Practice—Footcandles Maintained in Service	Illustration		Luminaire	Minimum Efficiency (Per Cent)
Tournament	30		(b)	Deep bowl wide spread reflector type	75
Club	20	(a)	(b)		
Recreational	10	(a)	(b)		

46. Tennis–Overhead Fluorescent

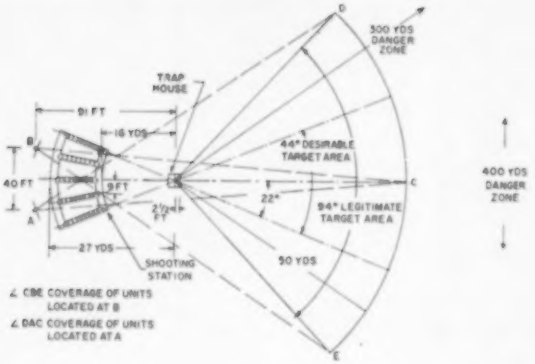
Class	IES Current Recommended Practice—Footcandles Maintained in Service	Luminaires
Recreational	10	Wide Spread

Mounting height: 30 to 35 feet above court suspended on messenger cable.

Illustrations show two possible arrangements but do not cover all o the possibilities with fluorescent luminaires.



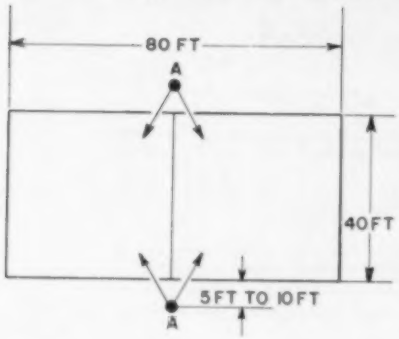
47. Trap Shooting



IES Current Recommended Practice—Footcandles Maintained in Service	*Floodlights*		*Mounting Height (Feet)*
	Type	*Class*	
Target (vertical surface at 105 feet)—30	2	GP	20
Firing point (general)—10			

Poles: 2.

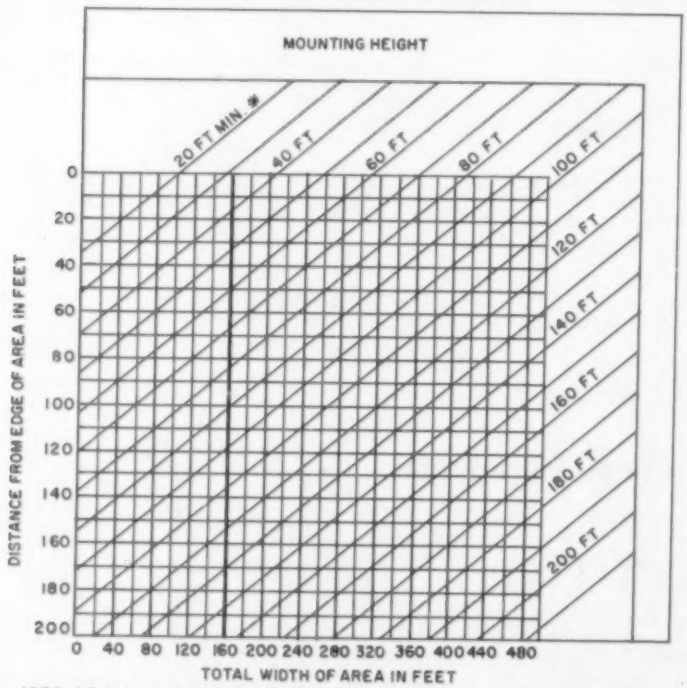
48. Volleyball—Outdoor Courts



Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Type*	*Class*	*Mounting Height (Feet)*
Tournament	20	5 or 6	GP O	30
Recreational	10	5 or 6	GP O	30

Poles: 4.

MOUNTING HEIGHT CHART



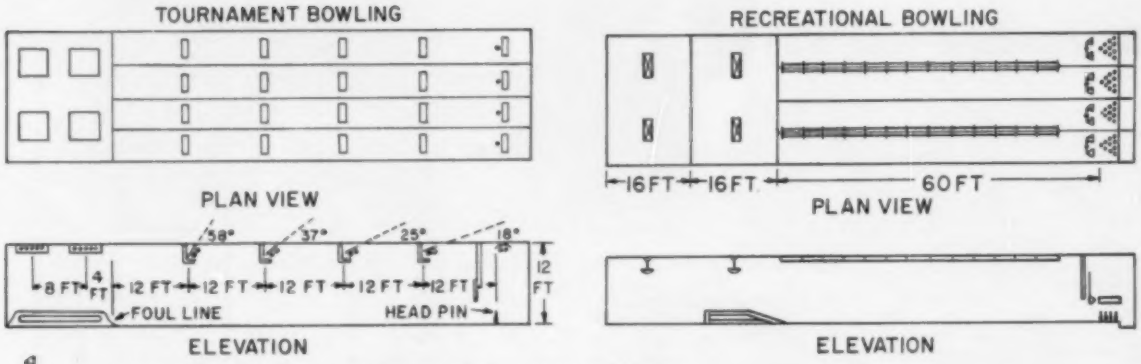
*FOR GROUND AREA SPORTS. 30 FEET IS MINIMUM FOR AREA SPORTS.

Mounting height chart for all sports areas—minimum height to bottom floodlight cross-arm. Read mounting height along diagonal at intersection of appropriate horizontal and vertical lines. For example, where Area Width = 200 feet and Pole Setback = 70 feet, minimum height of 80 feet is indicated by diagonal at intersection of 70 and 200 feet.

Recommended Layouts for Indoor Sports

Due to the wide choice of both lamps and lighting units, lamp sizes and quantities are not shown. The many factors governing the individual situation should be taken into consideration in recommending lamp sizes and quantities necessary to meet the desired classifications.

49. Bowling



REFLECTOR FLOODLAMPS, FLUORESCENT OR EQUIVALENT.

DIRECT-INDIRECT, FLUORESCENT OR EQUIVALENT, LOCATED OR SHIELDED TO AVOID SPILL LIGHT.

SEMIDIRECT-DIRECT, FLUORESCENT OR EQUIVALENT INCANDESCENT.

DIRECT FLUORESCENT TILTED 15° TO 60° FROM HORIZONTAL AND CONCEALED, OR EQUIVALENT INCANDESCENT.

DIRECT FLUORESCENT OR EQUIVALENT INCANDESCENT.

Class	*IES Current Recommended Practice*—Footcandles Maintained in Service*		
	Approaches	*Lanes*	*Pins***
Tournament	10	20	50
Recreational	10	10	30

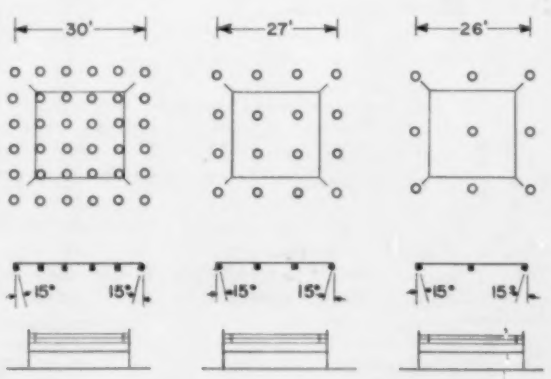
* Levels shown are based upon visual considerations. Otherwise for public attraction and increased business considerations, practice is as follows:

Class	*Approaches*	*Lanes*	*Pins***
Tournament	70	100	200
Recreational	50	70	150

** Vertical.

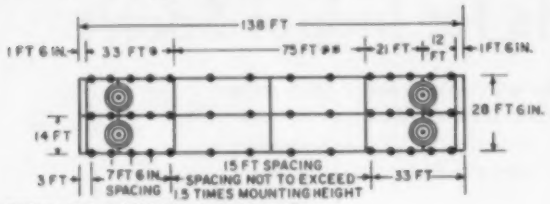
Mounting: Luminaires over alleys should be tilted approximately 15° to 60° from horizontal when they are mounted crosswise to the alleys. For continuous longitudinal rows proper shielding will be necessary. Bare lamps should be mounted behind a baffle which will effectively screen the lamps. Luminaires for the pins should be mounted behind the shield and close to the pins.

50. Boxing or Wrestling—Indoor Rings



Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Luminaire*	*Minimum Mounting Height (Feet)*
Championship	500	Direct (Concentrating Distribution)	18
Professional	200		
Amateur	100		

51. Curling—Indoor Rink



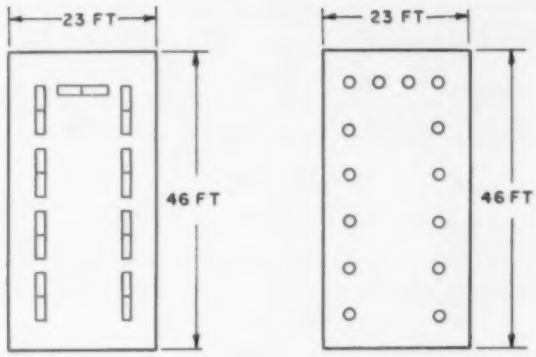
*TEES—HOG LINE TO HACK LINE
**RINK—HOG LINE TO HOG LINE

Class	*IES Current Recommended Practice—Footcandles Maintained in Service*		*Luminaires Required*	*Minimum Mounting Height (Feet)*
	Tees	Rink		
Tournament (Double Sheet)	20	10	Direct or Semi-Direct Wide Spread Distribution	12

52. Handball—Four-Wall Indoor

Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Luminaires*
Tournament	30	Direct Recessed (Spread Distribution Carefully Shielded)
Club	20	
Recreational	10	

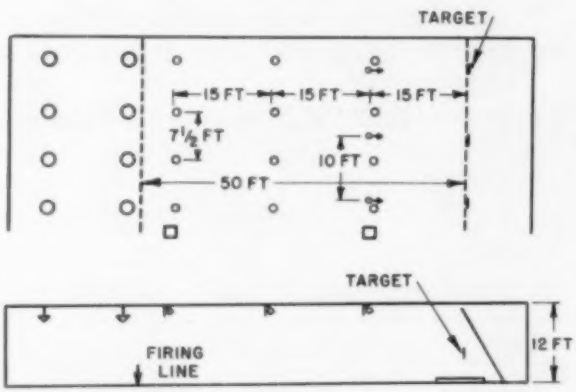
Ceiling Height: Approximately 23 feet.



53. Rifle and Pistol—Indoor Range

IES Current Recommended Practice—Footcandles Maintained in Service	*Symbol*	*Luminaires*
10 at firing point	○	Indirect
5 on range	◦	Directional
50 on target	○→	Directional

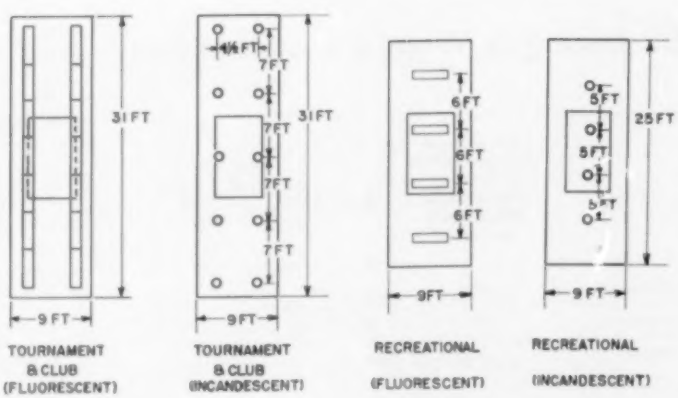
Ceiling Height: Approximately 12 feet.



54. Table Tennis

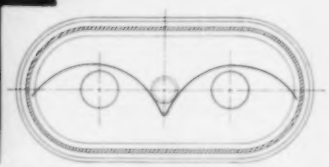
Class	*IES Current Recommended Practice—Footcandles Maintained in Service*	*Luminaires*
Tournament	50	Direct (Spread Distribution)
Club	30	
Recreational	20	

Mounting: Ceiling height approximately 12 feet.



A.I.A. File No. 31f

Below, Cross section view of a Luxaire unit.



INSTALLATION AT UNITED AIR LINES' PASSENGER CONCOURSE, NEW YORK INTERNATIONAL AIRPORT, NEW YORK, N. Y.

Lighting an Airport Service Area

LIGHTING OBJECTIVE: To provide illumination at an airport terminal ramp for jet aircraft loading, unloading and servicing and for taxiing the aircraft into the service area.

GENERAL INFORMATION: The service area extends 200 feet from each side of the passenger concourse. The concourse itself projects approximately 530 feet from United Air Lines' Terminal Building and has a roof height of approximately 27 feet.

INSTALLATION: Sixteen Pfaff & Kendall type 228VHO luminaires, each equipped with four 96-inch T-12 cool white 1500-ma fluorescent lamps, are installed on six-foot tapered aluminum poles mounted atop the concourse building, eight luminaires on each side of the building. Each luminaire consists of two individually adjustable Luxaire units of two lamps each (see drawing), with highly specular reflectors behind each lamp, and is completely enclosed by a Plexiglas envelope sealed at both ends by a heavy neoprene gasket. The over-all luminaire mounting height is 33 feet above ground level. Poles are slanted at a 50-degree angle above the horizontal as shown above.

The horizontal illumination level 100 feet from the building is two footcandles. The average over the 200-foot width is approximately three footcandles.

Architects: Skidmore, Owings & Merrill, New York, N. Y. Consulting Engineers: Syska & Hennessy, Inc., New York, N. Y.

Lighting data submitted by John F. Foulkes, Illumination Engineer, Facilities and Properties, United Air Lines, Chicago, Ill. and John Alvarado, Manager, Advertising & Sales Promotion, Pfaff & Kendall, Newark, N. J., as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y. This is one of 24 different sheets in Series XXV. Subscriptions to the entire series may be purchased from the Publications Office, IES Headquarters, or quantities of individual sheets, minimum 100, may be ordered.

Series XXV
2-61

A.I.A. File No. 31f

Design and Application of

OUTDOOR FLUORESCENT LAMPS

Satisfactory performance of fluorescent lamps exposed to variable ambient conditions has become increasingly important with the growth of outdoor lighting. This paper discusses the design requirements, performance characteristics and applications of jacketed and unjacketed 1.5-ampere, T10, fluorescent lamps—lamps designed specifically for outdoor environments.

By W. J. KARASH
A. L. HART

FLUORESCENT LAMPS have been used extensively, in almost every area of outdoor lighting, ever since their commercial introduction. The growth of this light source, for outdoor applications, has been in spite of severe limitations placed on the lamp by normal fluctuations in environmental conditions. Light output, efficiency, color, electrical characteristics, and starting voltage requirements are all strongly affected by the internal mercury vapor pressure,[2-4, 6-13] which in turn is governed by the environmental factors of temperature, wind velocity, wind direction, etc. The internal mercury vapor pressure is determined by the temperature of the "cold-spot"—the coolest spot of the bulb wall.[1, 2, 3, 5, 6] Maximum light output is obtained at a "cold-spot" temperature at or near 100F.

Fig. 1 is representative of the drop in light output with departure from optimum "cold-spot" temperature. Reported data,[1-13] probably due to variations in ballasting and experimental technique, show minor deviations from Fig. 1. Basically, however, the reported data all show:

1. For "cold-spot" temperatures above 100F, lamp watts and light output decrease gradually with increasing temperatures. Lamp efficiency decreases at a considerably lower rate.

2. For "cold-spot" temperatures below 100F, lamp watts decrease at a moderate rate with decreasing temperature. Lamp efficiency and light output, however, fall almost precipitously.

In addition to the rapid fall-off of light output with decreasing "cold-spot" temperature, contin-

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa. AUTHORS: Large Lamp Department, General Electric Co., Cleveland, Ohio. Accepted by the Papers Committee as a Transaction of the IES.

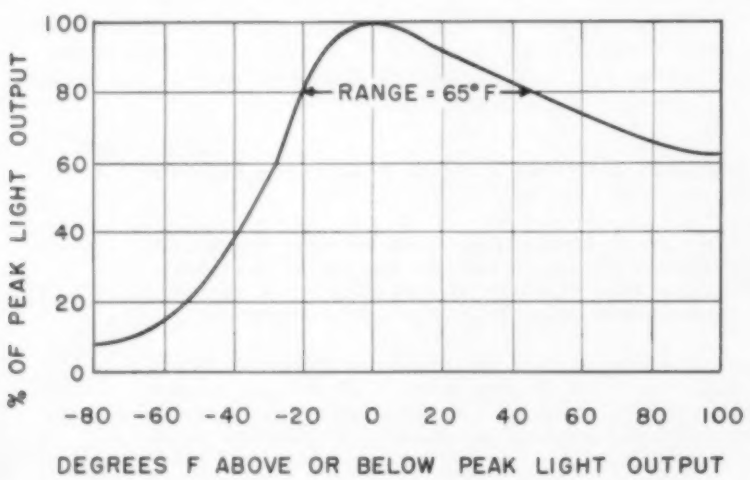


Figure 1. Typical light output vs temperature characteristic showing drop in light output with departure from optimum "cold-spot" temperature. After Herrick and Wenner.[4]

ued operation of longer fluorescent lamps (6'-8') at "cold-spot" temperatures of 30F or more below the optimum, results in a "pumping" phenomenon.[14] Striations appear in the discharge, mercury is "pumped" from the ends of the lamp toward the center, and eventually only the center section of the lamp exhibits an appreciable luminosity. The time required before appreciable dimming of the lamp ends is apparent depends upon total quantity and distribution of mercury within the lamp, lamp current, fill gas, fill pressure, and "cold-spot" temperature. A detailed and quantitative examination of the "pumping" phenomena is the subject of a future paper by Dr. Carl Kenty.

Outdoor Application Problems and Possible Solutions

Until recently, all fluorescent lamps were designed for optimum performance as bare lamps, in still 70-80F air. The basic problem for outdoor applications was one of maintaining a constant, or near constant, internal mercury vapor pressure over a wide range of environmental conditions. At low temperatures, and especially for exposed or single-lamp luminaires, the principal problem was conservation of heat and maintaining the "cold-spot" temperature near 100F. Cold-spot temperatures below 60-70F result in drastic reductions in light output. For summer conditions, and especially for totally enclosed multi-lamp luminaires, the problem was one of adequate heat dissipation.

Luminaire designs and proposals, for approaching ideal lamp performance, include:

1. Maintaining a constant lamp ambient under a wide range of environmental conditions by means of thermostatically controlled ventilation or heat exchangers.[8] In this approach, the luminaire design maintains a lamp ambient of at least 40F, even under the most adverse low temperature conditions. At higher temperatures, within the limitations of the heat exchangers or ventilators, lamp ambient is maintained in the 70-80F range.

2. Maintaining a constant, localized "cold-spot" temperature. In this approach, the luminaire design maintains the bulb wall temperature above 100F, even under the most severe low temperature conditions. Localized cooling, such as thermo-electric spot cooling,[3] or a nonlinear "cold-spot" heat exchanger, would maintain the internal vapor pressure near optimum over a wide range of environmental conditions.

3. Lamp designs where the general bulb wall temperature is above 100F, and where a single "cold-spot" or area is normally below 100F, over the entire range of expected environmental conditions. Thermostatically controlled auxiliary heat to the "cold-spot" would maintain optimum mercury vapor pressure over the entire range of use conditions. Such lamp designs include:

A. Partially jacketed lamps with externally heated end chambers.
B. Extremely highly-loaded lamps with an externally heated mercury reservoir appendage.
C. Extremely highly-loaded lamps with an externally heated, mercury-amalgam control point or appendage.

Unfortunately, the above lamp designs are too costly to incorporate in multi-use commercial lamps, and would also requie a substantial amount of auxiliary equipment and controls for successful operation. The lamp design problem, for outdoor applications, becomes one of matching optimum performance *vs* environmental conditions for the greatest range of actual use.

Referring to Fig. 1 and assuming that the light output is not to fall below 80 per cent of maximum under extreme conditions, the range of ambient temperatures for a given wind velocity and direction is approximately 65F. If we allow 50 per cent as the minimum light output, the range is extended to approximately 140F. Due to the asymmetric shape of the "Light Output *vs* Bulb Wall Temperature" function, maximum light output occurs nearer the low temperature end of the range.

The best lamp design compromise, therefore, is one in which the "cold-spot" temperature will not be more than 30F or so below optimum, for the most adverse low temperature-high wind velocity conditions. Other desirable design requirements include:

1. Successful starting and operation on existing ballasts.
2. Physical interchangeability with lamps in existing outdoor luminaires.

Lamp Designs and Performance

Experimental lamp designs and tests covered the following parameters:

1. Bulb diameter.
2. Lamp loading.
3. Filling gas composition and pressure.
4. Full and partial jackets of various diameters.

Extensive tests in the laboratory and cold rooms showed the following lamp designs to be the best all-around solution:

1. T-10 bulb: Smaller diameters than this give excessive depreciation, run into starting problems, and may result in poor lamp factor on existing 1.5 ampere ballasts; larger diameters than T-10 sacrifice initial efficiency, lumens, lamp watts, and bulb wall temperature.

2. 1.5 ampere nominal loading for operation on

existing ballasts and to maintain a high bulb wall temperature under adverse conditions.

3. 2.5 mm of argon with a small percentage of neon. Lower pressures sacrifice maintenance, higher pressures give lower efficiency. The small percentage of neon gives a better lamp-ballast match, with existing 1.5 ampere ballasts, without an undue loss of lamp life.

4. Full length, T-14 jackets over T-10 lamps. Partial jackets have merit in certain applications. The exposed lamp ends serve as "cold-spots" and reduce the internal mercury vapor pressure for any given set of environmental conditions. The net effect is to move the peak light output point toward higher ambient temperatures. However, these are outweighed by the disadvantages of partial jackets which include:

A. Susceptibility to localized drafts.
B. More rapid fluctuations in light output with transient changes in wind or ambient temperature.
C. Variability in performance characteristics with design and condition of the weatherproof lamp holders.

Smaller diameter jackets fail to provide sufficient thermal insulation; larger diameters result in increased thermal losses due to increased convection currents. Other disadvantages of larger diameter jackets include bulk, cost, and possibly non-interchangeability with existing lamps.

Fig. 2 shows the performance characteristics of the new and an existing lamp design: in open, single-lamp luminaires for poster-panels, for end-on wind velocities of 5 and 15 mph. It should be pointed out that these data are for a specific combination of luminaire, ballast, and tightly fitting weatherproof lamp holders. Changes in wind direction, wind velocity, or condition of the weatherproof fittings will, of course, shift the maximum points. The condition and fit of the weatherproof lamp holders, inasmuch as they provide additional thermal insulation to what would normally be the

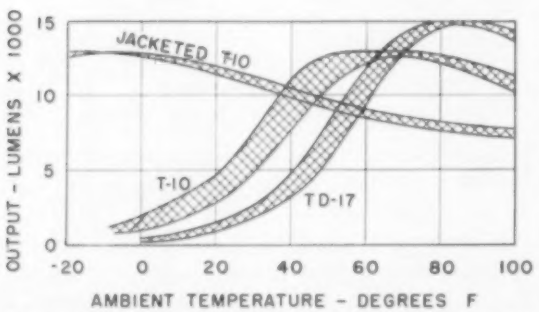


Figure 2. Light output *vs* ambient temperature for eight-foot fluorescent lamps in open, single-lamp, floodlights. Wind velocities: 5-15 mph (lengthwise to luminaire). Commercial, two lamp-series, outdoor ballasts. New, tightly fitting, weatherproof, lamp holders.

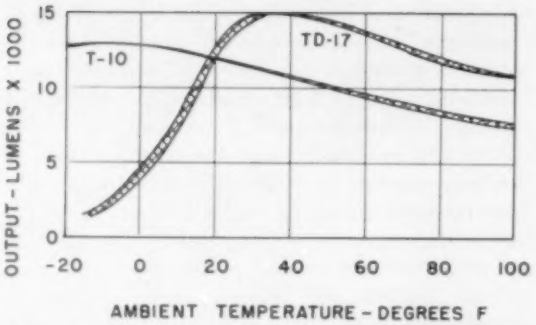


Figure 3. Light output *vs* ambient temperature for eight-foot fluorescent lamps in tightly sealed, single-lamp floodlights. Wind velocities: 5-15 mph (lengthwise to luminaire). Commercial, two-lamp-series, outdoor ballasts. New, tightly fitting, weatherproof, lamp holders.

"cold-spot," will have the greatest effect on the jacketed T-10 lamps. Under average field conditions, the curve for the jacketed T-10 lamp would be expected to shift 10F or so, to the right, relative to the other lamp designs.

Fig. 3 gives the performance characteristics for an unjacketed T-10 and a TD-17 design in a closed fixture, for 5 to 15 mph wind velocities. It should be pointed out that these data were obtained with tightly sealed luminaires. Attempts to define and duplicate the average fixture in the field would have been most difficult, and would have resulted in erratic, non-duplicable data. For typical equipment in the field, due to equipment design and maintenance, a shift of 10-15F to the right is quite likely.

Application of T-10 and Jacketed T-10 Lamps

The most effective application of these new lamps (pictured in Fig. 4) will be achieved through a careful assessment of their intrinsic output *vs* temperature characteristics, the auxiliary equipment in and with which they are to be operated, the specific lighting requirements, and the environment in which they must operate. The latter becomes especially important in that these two lamp designs produce maximum light output at temperatures significantly lower than conventional lamps.

In evaluating local climatic conditions, the significance of the actual operating periods of a lighting system is often inadvertently overlooked. Most commercial outdoor lighting is operated from dusk to approximately midnight. This means that a lighting system may operate as much as 5 to 7 hours a night in the winter but only 3 to 4 hours a night in the summer. The predominant temperatures must therefore be weighted in terms of the operating time if the evaluation is to be valid.

Another consideration is the data available from

Figure 4. Photograph of jacketed and unjacketed T-10 fluorescent lamps.

the United States Department of Commerce Weather Bureau, which are used to assist in determining local conditions. These data, as generally published, cover the extreme high and low temperatures that have occurred over an extended number of years in a given locality. Also covered are the normal maximum and minimum that can be expected to occur on a given date. Both of these sets of data can be misleading if used without caution. The extremes in temperature are rare and do not necessarily occur when the lighting system is in operation. The "normal" temperatures, useful as an indicating device, do not account for the spread of temperatures that can occur. For example, the normal minimum temperature for Atlanta, Georgia, in January is 37F. However, an examination of records for 1954, a random choice, indicates that the daily 7:00 pm temperature readings for the month ranged from 28F to 65F. The effect of this temperature spread on lamp performance is obvious.

A statistical compilation of daily temperatures that can be expected to occur during a given set of lamp operating periods could prove helpful to the outdoor lighting designers. This is, however, a project beyond the scope of this paper.

In addition to the above, lighting designers should be aware that in many outdoor lighting applications, considerations of safety, advertising value, and working conditions may make it imperative that sufficient light be available under the most adverse conditions. Where this is the case, the approach may necessarily be to take advantage of the shape of the output *vs* temperature curve and design to meet the low temperature requirements.

Jacketed T-10

The characteristics of the jacketed T-10 are:

1. Maximum light output in the 0-degree region when operated in open equipment.

2. Light output does not fall below 50 per cent over a temperature range of —20F to 100F, when operated in open equipment.

Use of the jacketed T-10 is indicated (1) wherever it is desirble to operate an exposed fluorescent lamp at low ambient tempearatures; (2) where near maximum light output under low temperature conditions is a major design factor; and (3) where reasonable light output is required over a wide range of operating conditions.

Lighting equipment for the jacketed T-10 includes open floodlights (either single or multiple lamp), and bare lamp channels either open or concealed in coves, cornices, light bands or troughs. The jacketed T-10 will find application in almost every phase of outdoor lighting including such varied areas as outdoor advertising (Fig. 5), building floodlighting, service station lighting, and warehousing and loading dock operations.

Indoors, use of the jacketed T-10 will be limited to those areas where extremely low temperature

Figure 5. Typical outdoor advertising application of T-10 F lamps in an enclosed luminaire or jacketed T-10 in an open luminaire.

Figure 6. Frozen food warehouse lighted to 25-30 fc in aisles, with eight-foot jacketed T-10 lamps. Industrial type luminaires are equipped with low temperature ballasts.

conditions preclude the use of previous design of fluorescent lamps in open units. It has already proved useful in refrigerated storage areas for frozen food where sub-zero ambient temperatures are maintained. (Fig. 6.)

Unjacketed T-10

From Figs. 2 and 3, the performance of the T-10 can be summarized as:

1. A light output characteristic, when operated in tightly enclosed single lamp luminaires, similar to the exposed jacketed T-10 above.

2. Maximum light output in the 60F region when operated in open equipment.

3. Light output, in open equipment, exceeding 50 per cent of maximum over a range of ambient temperatures from approximately 30F to well above 100F.

The T-10 lamp is useful in the application fields listed above where covered units are required for physical protection of maintenance purposes. In the warmer parts of the country, where low temperatures are infrequent, it is being used in open equipment. As with previous lamp designs, the performance of the T-10 in open equipment will depend on the protection afforded the lamp by the luminaires and by location of the equipment with respect to potential windbreaks. When the ambient temperature approaches 30F, reduction in light output approximating 50 per cent of maximum must be expected. (See Fig. 2.)

The small diameter, high brightness (12.75 candle/sq. in.) T-10 will lend itself to new designs in multiple lamp luminaires, especially for increased light control or reduction in luminaire size. Where enclosure in multiple-lamp luminaires is required to minimize loss of control and efficiency due to dirt accumulation, temperatures may increase sufficiently to require external mercury pressure control through local or generalized cooling of the lamps.[2]

Summary

Two new fluorescent lamp designs have been introduced: jacketed and unjacketed, T-10, 1.5 ampere. These are the first fluorescent lamps designed specifically for outdoor applications. The unique "Light Output *vs* Ambient Temperature" characteristics of these lamps greatly extends the field of outdoor applications, and removes many of the previous limitations on applications and luminaire design.

Acknowledgments

The authors wish to express their appreciation to T. B. McMullen, P. J. Underwood, D. A. Nelson, and P. R. Herrick for their valuable contributions in the design and testing of these new lamps.

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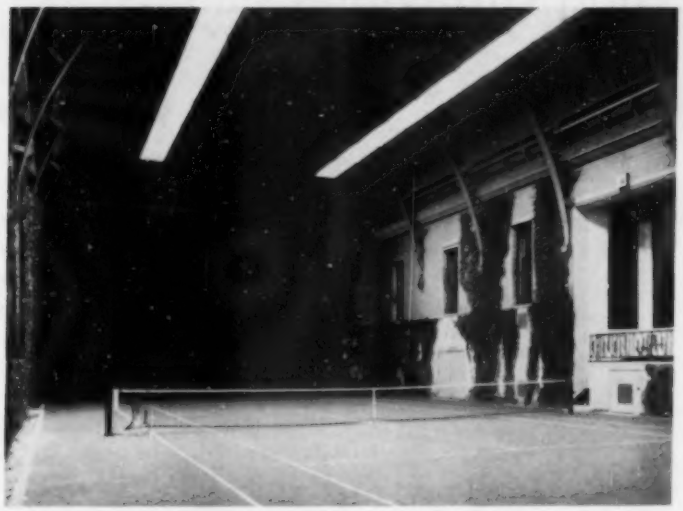

INSTALLATION AT THE HANGAR RECREATION ASSOCIATION, CEDAR ROAD, BEACHWOOD, OHIO

Lighting for Indoor Tennis

LIGHTING OBJECTIVE: To provide a well lighted, comfortable environment for playing indoor club class tennis.

GENERAL INFORMATION: The ivy-covered interior walls of this building convey a pleasing outdoor atmosphere and are meant to dispel any impression of playing inside a confining space. The location shown above measures 56 feet by 118 feet. The vaulted glass ceiling varies from approximately 50 feet above the floor at the center to 25 feet at the sides. Colors and reflectances of the major room surfaces are: lower walls, grey (40%); upper walls, tan (30%); ceiling and wall trim, green (35%); and clay floor (14%). The ivy with a low reflectance of about 4 per cent provides a good low-brightness background for the moving tennis ball.

INSTALLATION: Twenty-two Lighting Products Inc. catalog No. 1615M4-96 louvered fluorescent units are suspended in two rows of 11 units each, approximately 27 feet apart and 32 feet above the floor. Each unit is modified by enclosing the top with a white finished reflector and is equipped with four 96-inch TD-17 cool white extra-high-output lamps (grooves mounted sideways).

After about 2000 hours of lamp operation, illumination at stroke height averaged approximately 75 footcandles in the forecourt and 60 footcandles in the backcourts. Brightnesses were:

luminaire at about 55 degrees	865 fL
at about 70 degrees	460 fL
walls, ivy on end	1.7 fL
ivy on side	3.3 fL
lower side	20 fL
upper side	13 fL

Lighting designed by Kirk M. Reid, General Electric Co., Nela Park, Cleveland, Ohio. Lighting Consultant and Electrical and Structural Designer, George E. Blain. Consulting Architect, Francis Almirall.

Lighting data submitted by Kirk M. Reid as an illustration of good lighting practice and to aid in the design of similar installations.

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Air Ions Using Ultraviolet Lamps

By RUDOLPH NAGY

This paper describes methods for generating negative air ions using bactericidal lamps; discusses current research on physiological effects of air ions on man and possible future roles of air ions in the application of germicidal lamps.

Ultraviolet lamps have been reported to produce air ions. Leboucher,[1] Bachhaus[2] and Rathier[3] have used mercury lamps to ionize the air so as to discharge static electricity from celluloid and paper. Wait[4] showed that air ions near a mercury lamp had a very high mobility while air ions a short distance away from the lamp were large and had a very low mobility. Norinder and Siksna[5] reported similar results. They believed that the air ions were produced by the photoelectric effect from surfaces and gases. They observed as high as 40,000 ions/ml near a 100-watt mercury lamp. The half-life of the air ions in their test was about one half-hour.

Radiation from ultraviolet lamps cannot ionize pure air. Ditchburn[6] reports that the threshold for the first ionization of oxygen corresponds to a wave length of 1019A with a maximum absorption at 950A. The threshold for nitrogen is 792A with a maximum absorption at 750A. The shortest wave length radiation from some of our bactericidal lamps is 1849A with over 90 per cent of the emitted energy being at 2537A. Thus, any air ions observed near an ultraviolet lamp must be created by attachment of an electron to oxygen or to dirt particles. Oxygen or dirt particles having an extra electron would result in a negative air ion while a dirt particle which has lost an electron would be a positive air ion.

Photoelectric Effect

One of the earliest and most investigated methods of producing electrons has been by the photoelectric effect. As early as 1887 Hertz showed that ultraviolet radiation could liberate electrons from a zinc spark gap. In subsequent years many metals and compounds were tested in air to determine the relative number of electrons liberated by radiation.[7,8,9] Actually these early investigators measured the number of ions because the electrons would have attached themselves to oxygen or dirt particles in the air. The number of ions generated using a given metal as the photoelectric surface would depend upon the amount of polishing or treatment of the metal. Generally the more electropositive metals liberated the greatest number of electrons resulting in the greatest generation of ions. Oxide formation on the metal surface was found to reduce the electron emission, while reduction with hydrogen or the formation of a sulfide enhanced the emission of electrons from some metals.

In order to eliminate the effects of air on the photoemission of electrons, most of the metals in subsequent years were retested in vacuum. The photoelectric work function, the energy necessary to remove an electron from the metal, has now been determined for practically all of the known elements. The photoelectric work function is greater for metals of higher density. The metals having a low work function are unstable in that they readily combine with water, oxygen and carbon dioxide in the air. The more stable metals when exposed to radiation from bactericidal lamps emit electrons; however, the yield is very low. Metals such as zinc, aluminum and silver are soon coated with an oxide film which results in a higher work function than for the pure metal.

Oxygen as adsorbed gas or as oxide, nitrogen, or the halogens, or any electronegative element on the surface of an electropositive element will produce an electrical double layer with the negative side away from the surface. The result is that the electrons liberated by radiation are repelled by the negative field back into the metal.

If the metal deposited on the surface has a smaller affinity for electrons than the underlying metal,

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i.e., electropositive, it will tend to lose its valence electrons to the lower layer and double layer-positive outwards will be set up. This imposes a potential positive outward equal to the strength of the double layer and thus reduces the work function. The layer of electropositive ions on the surface acts as a grid of a thermionic tube. DeBoer[8] states that the electric field which the ion can cause at the metal surface is very great, of the order of 2.5 x 10^6 volts/cm.

DeBoer, among many other investigators, has shown that an increased photoelectric effect can be obtained by use of an electronegative immediate layer. That is, if an electropositive metal is deposited on a highly electronegative element, such as oxygen, which in turn is on another metal, there is a large increase in photoelectron emission. This can be explained on the basis that a stronger dipole is produced resulting in a lower work function. Such intermediate layers have been used in the making of phototubes such as the Ag-O-Cs which has a very high electron emission. Unfortunately this material cannot be used in the air to produce ions because of its instability. However, the principle can be applied to the development of a stable material to be used with bactericidal lamps.

Preliminary Tests

In the practical application of ultraviolet radiation, the lamp is generally enclosed in a metal structure. This metal releases electrons when irradiated. A number of wall-type ultraviolet deodorizing units were obtained to determine the quantity of air ions they generated. Generally, two 4-watt S-11 ozone lamps are enclosed in an aluminum or stainless steel housing.

The number of ions formed was determined by collecting them onto a series of aluminum plates and measuring the resulting current using a Keithley electrometer. Air was drawn through the deodorizing units into the instrument which is shown schematically in Fig. 1. The voltage applied to the deflecting plates of this instrument was 50 volts, sufficient to remove air ions having mobilities of from 0.01 to 2.2 cm/sec/volt/cm. The number of air ions per cm^3, N, was calculated as follows:

$$N = \frac{I}{q \times C}$$

Where I = Current read on electrometer, in amperes

$q = 1.6 \times 10^{-19}$ coulombs

C = Milliliters of air/sec.

The number of ions/ml observed from various types of deodorizing units is shown in Table I.

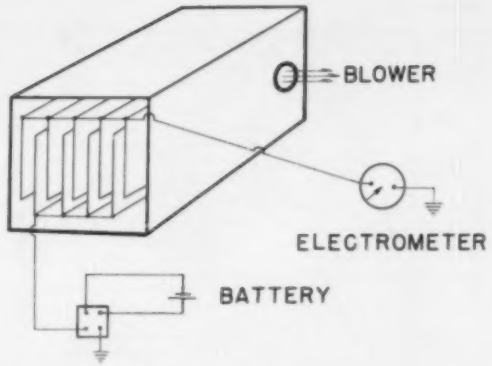

Figure 1. Schematic diagram of plate collector for the measurement of air ion concentrations.

The nearly three-fold difference in the number of ions/ml generated by these units was attributed to the composition of the housing. This was proven by exposing various metals to a 16-watt ultraviolet lamp. The metals were cut into strips, so that the areas were nearly, equal and placed on either side of the lamp. The variations observed for any particular metal were caused by the degree of polishing or cleaning of the surface. The strips of metal were grounded or connected to a negative terminal of a half wave rectifier. Results of some of the tests are given in Table II.

The aluminum foil appeared to be a promising material for the generation of ions. A number of

TABLE I.

Manufacturer	Negative ions/ml
A	6600
B	2200
C	5700
D	3700
E	7000
F	2600
G	2800

TABLE II—Number of Negative Air Ions/ml Observed from Various Materials when Exposed to a 16-Watt Bactericidal Lamp.

Metal	Negative Air Ions/ml Ground	—400V
Galvanized iron	9,100	26,000
Silver	32,000	39,000
Copper	4,600	78,000
Copper	22,000	78,000
Copper oxide	52,000	78,000
Iron	3,900	10,400
Lead	4,600	130,000
Lead sulfide	65,000	104,000
Gold (on copper)	130,000	286,000
Gold (on copper)	156,000	260,000
Silver (on copper)	65,000	91,000
Silver (on copper)	78,000	156,000
Silver sulfide	104,000	182,000
*Aluminum Foil A	78,000	310,000 (—300V)
*Aluminum Foil B	65,000	260,000 (—300V)
*Aluminum Foil C	65,000	286,000 (—300V)

*Area of foil was about six times larger than other metals.

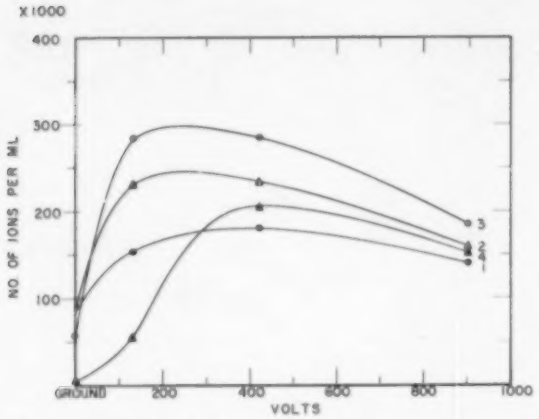

Figure 2. Effect of voltage on output of negative air ions from differently prepared emissive surfaces. (1) Copper wire plated with thin layers of silver and gold; (2) Copper wire plated with a heavier layer of silver and gold; (3) Copper wire plated with a heavy layer of silver and gold; (4) Copper oxide on copper wire.

samples of aluminum alloys with magnesium, titanium and lithium were obtained with the hope that an even greater number of ions could be generated. The work function of lithium and magnesium should have been lower than that of the pure aluminum; however, the available alloys were not as electron emissive as the foil.

The aluminum foil rapidly loses one-half of its emissivity in about ten hours; however, the subsequent deterioration is very slight. The initial loss is dependent upon the type of lamp used. As an example, a quartz lamp oxidizes the aluminum surface more rapidly than does a regular bactericidal lamp.

Silver, electrolytically plated on copper, also had a high emissivity when exposed to bactericidal lamps. The silver is slightly more electropositive than copper,[9] thus producing a dipole which would aid the ejection of electrons. However, silver is also readily oxidized and reacts with hydrogen sulfide in the air. A thin layer of gold electrolytically placed on top of the silver protected the surface without reducing the electron emission. The critical thickness is about 100 atomic layers.[8] Beyond this thickness the surface work function becomes more nearly that of pure gold.

The emission of electrons from composite layers is greatly influenced by the application of an electric field. Some of the surfaces show a steep increase in emission while others show only a minute effect. Fig. 2 also shows the influence of very high voltages. Those emissive materials were prepared by electrolytically plating a copper screen with silver and protecting it with a flash of gold. The differences observed can be accounted for by variations in the thicknesses of the various metals or oxide on the copper. The plated screen was wrapped around a 16-watt ultraviolet lamp and the ions were collected with a plate collector. The lower ion output at the very high voltages probably occurred because the rate of attachment of electrons to oxygen may be influenced by the electric field. Variations were also observed by changing the geometry of the emissive surfaces.

A number of different types of units were prepared to study the geometry in relation to the number of ions produced. A 16-watt lamp was used because of its small size and very high output of bactericidal radiation. In all instances the copper-silver-gold screen was placed around the lamp. A negative voltage was supplied to the screen using a 90-volt battery or a half-wave rectifier. The ion output of a number of experimental units was as follows:

Unit No.	cfm	Ions/ml
1	20	50,000
2	20	26,000
3	50	180,000
4	50	100,000
5	32	72,000
6	64	46,000
7	13	104,000
8	50	195,000
9	48	130,000

The greatest number of ions generated was from units having a streamlined flow of air. Turbulent air on the inside of the duct will remove the ions either by recombination with the wall surfaces or by producing ions of smaller mobility, as observed by Wait.[4] Fig. 3 is a schematic of a unit designed to produce a large number of ions as well as to disinfect the air by destroying most of the airborne bacteria and viruses.

Physiological Effect of Ions

Air normally contains a small number of negatively and positively charged gas molecules and particles. Over a period of sixty years there have been many reports that negative air ions produce a beneficial effect while positive ions generally have been considered harmful. Yaglou[11] spoke of

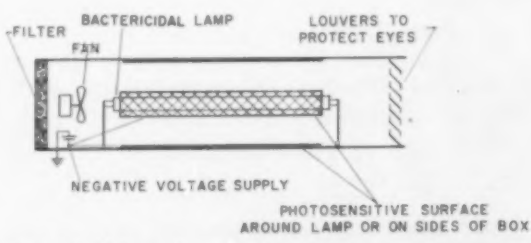

Figure 3. Schematic of s[illegible] eamlined ion generating unit.

negative ions exerting a normalizing influence of a desirable character while positive ions resulted in headaches and nose and throat irritation. It has been often reported that the small variation in the number of ions in air may produce physiological and psychological effects in weather-sensitive individuals and may explain why some people are uncomfortable and even become ill in some of our present air conditioned rooms. The number of ions under such conditions may be less than 1000/ml.

Dessauer[12] for the past thirty years has been using about one million negative ions/ml for the treatment of climate-sensitive individuals. Bierman[13] in 1933 reported that negative ions can relieve asthma and sinusitis. Recently, Kornblueh[14] reported relief of "hayfever" in many individuals treated with negative ions. Cauer[15] reported success in the treatment of silicosis and in shortening the duration of "colds." Most of the early investigators used heated magnesium oxide or a negatively charged fine wire for their source of ions. Picard[16] in 1924 was using an ultraviolet lamp inside of an aluminum sphere, thus using the photoelectric effect described in the first part of this paper. Winsor, et al[17] and Erban[18] just recently demonstrated that large numbers of positive air ions are harmful even to healthy individuals. Erban used over 4 million ions/ml on a group of people for one hour, three times a week for eight weeks. The negative ions had no ill effect, while the positive ions *did* influence the ratio of a number of the blood constituents. There is evidence by Krueger and Smith[19] that the action of the ions on the body may be through a reaction with specific body enzymes. Many more data are necessary on the biochemistry of the body before the mode of action of ions can be stated.

This lack of knowledge on the mechanism of ions immediately raises a question as to our true understanding of the mode of action of ultraviolet radiation on bacteria and viruses and its general physiological effect. A review of the literature on the physiological effects of ultraviolet radiation produces many contradictions.

These contradictions can now, in some instances, be rationalized on the basis that the reported ultraviolet effects were, in fact, the sum of the effects of ultraviolet radiation and ions. Kornblueh[20] has been the first to point this out. There are many tests with bactericidal lamps in recent years in schoolrooms, nurseries and poultry farms that could not always be duplicated. There is no doubt now that in some of these tests an unknown number of negative ions was also produced. This new view on the synergistic action of bactericidal radiation and ions should open a new field in the research on new applications for bactericidal lamps.

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20. Kornblueh, I. H.: "Brief Review of Effects of Artificial Ionization of the Air and Ultraviolet Radiation," *Intl. Jour. Bioclimatology and Meteorology*, Vol. II, 1958, Part IV, Sec. C6e.

DISCUSSION

DAVID G. FLEMING:* The author describes the phenomenon of electron escape from metallic surfaces bombarded with ultraviolet radiation. It represents an interesting study of the photoelectric work function in air and the problems unique to this situation.

The electrons clearing the surface of the target material have a half life of the order of microseconds. Small, highly mobile ions are created when these electrons collide with oxygen or water vapor molecules. Larger ions with lower mobilities are formed by the contact of small ions with larger molecular aggregates. The absolute number, the polarity and the size distribution depend upon the number of condensation nuclei present in the air.

Nowhere in the presentation does the author describe environmental conditions during measurements. We have observed that the number of ions generated in a fixed system varies with such factors as the relative humidity, natural ion background level and the amount of particulate matter in the air, as well as target area. For example, if a fine water spray is added to the air prior to passing over the target material, the number of ions generated will increase markedly, since more small molecular aggregates are available for the free electrons. If, on the other hand, smoke is introduced into the system, the number of small ions generated will decrease since smoke contains many condensation nuclei.

An alternate explanation for the increase in ion production as a result of placing a negative bias on the target is the fact that electrons escaping from the surface of the

*General Electric Co., Cleveland, Ohio.

target material will be repelled by the like charge on the target and will not fall back to the surface. In addition, there is a less likely chance of building up a positive charge in the superficial layers, which may occur when a sulfide or oxide film develops. This might explain the generation of ions from the copper oxide on copper target material.

Regarding the biological effects of atmospheric ions, the author creates the impression that negative ions exert a beneficial effect while positive ions are generally considered harmful. A careful study of the literature will reveal that the results are not at all cut and dried. The older literature must not be taken at face value because of very severe limitations of experimental instrumentation and technique, such as the use of charged magnesium oxide dust as the ion carrier.

For many of the claimed definite effects there are other papers in which no effects or opposite effects are reported. Blood pressure can go up or down, negative ions can sedate or alert you, etc. The reported effects of regional and seasonal changes will not stand up to careful scrutiny. Kreuger and his associates have made splendid progress on the study of isolated systems in experimental animals as have some Russian workers, but these results are unverified, and cannot be extrapolated to man. This is not to state that atmospheric ions may not have an influence on humans, but rather that the results to date have been much too variable to permit any definite statements. What is most sorely needed at present is reliable data. For example, the concept of the synergistic action of ultraviolet light and atmospheric ions is based on a few casual retrograde observations. The idea, however, does merit systematic investigation.

The effects of atmospheric ions on man will remain a jumble of observations based on very insecure scientific foundations until the experiments are repeated, controlling other factors in the environment such as temperature, relative humidity, barometric pressure, condensation nuclei, and atmospheric gases.

RUDOLPH NAGY:* Dr. Fleming and I agree that more research is necessary on the generation of air ions as well as on their biological effects.

The background level of ions in a closed laboratory is generally very small—only a few hundred per cc. Smoke does reduce the number of small ions and we do not permit smoking when tests are in progress. Our observations on the effect of humidity would indicate that the moisture, rather than the number of ions, increased leakage over the polystyrene insulators.

The negative bias on the photoemissive material does repel the ions, as Dr. Fleming stated. However, the negative bias in sulfides and oxides also appears to produce a temporary polarization in the surface. For example, if a negative bias of −250 volts is applied to the compound, a considerable number of ions are recorded and more ions will be observed at −500 volts. However, if we now reduce the voltage to −250 volts, the number of ions will be nil for a short time, indicating polarization.

There is voluminous literature, which extends back for nearly 60 years, on the biological effects of negative ions. Some of this literature is contradictory. However, ion therapy has been used in Europe since before the war. Admittedly, we do not know the mechanism of action of ions on the body. This can be said of many of our drugs. Some of the publications of recent years have greatly stimulated research, so that the answers to Dr. Fleming's questions may be supplied in the not-too-distant future.

*Author.

Lighting Supports Theme of Airlines Office

In keeping with the travel theme of the KLM Airlines office in Chicago, Ill., this unique lighting arrangement is designed to depict the legendary flying boats of Swedish mythology. Fixture shielding is provided by white translucent "Fota-Lite" glass with integral baked-in louvers at a 45-degree cutoff. The louvers direct the light away from the walls and toward the center of the office, resulting in uniform distribution on desks and other working areas.

The second walls, which are curved, are colored white for increased reflectance. The second ceiling, a blue white, is also curved, but to a greater degree than the walls. It is affected only slightly by the lighting arrangement, thus creating the illusion of depth and sky. Visual contrast was achieved by painting black the exposed sections of the basic walls and ceiling.

The lighting units, suspended from struts set at a 30-degree angle with the vertical, are set parallel with the horizontal. A feeling of additional depth is created by the open area between the false ceiling and walls and the basic walls and ceiling.

Fixtures were designed by Harry Weese and Associates. Photo and data courtesy of Morris Kurtzon, Inc., Chicago.

LIGHTING NEWS

Lab Planned for Study of Light As Key to New Electronics Fields

Plans for a "Photo-Optronic Laboratory" to study the nature of light in its application to electronics and chemistry have been announced by Henry C. Jones, president of Electrada Corp., Beverly Hills, Calif. Studies in the laboratory are expected to contribute to developments in molecular electronics, the next major step in electronic technology.

Because of the very small amounts of matter involved in molecular electronics, light plays an important part as a source of energy, an information transfer medium and a yardstick for extremely accurate measurements. The new laboratory will be equipped to perform very precise measurements of the physical and chemical effects of light, such as the speed and resolution of film emulsions and other light-sensitive coatings, within microsecond-micron range. Special devices to study the effects of light on crystals and photo-conductors will also be installed. In addition, the laboratory will be capable of accurate testing of cathode ray tubes, monoscopes and photo transducers as well as other photoelectric devices.

Robert M. Lemmen, who has served in technical management and research positions with the U. S. Air Force and several major electronics manufacturers, will head the new facility. The laboratory is now under construction in Culver City, Calif., and is expected to be in operation by November 15, 1961.

93 Attend Ohio Valley School Lighting Symposium

A major undertaking of the Ohio Valley Section of IES early in the 1960-1961 year was co-sponsorship of a school lighting symposium on November 30, 1960 at the Princeton High School in Princeton, Ohio. The meeting, also sponsored by the Cincinnati Gas & Electric Co. and the Union Light, Heat and Power Co., was planned in response to many inquiries on proper classroom lighting. Ninety-three school officials, utility representatives and other IES members attended.

Program included talks by James F. Kneisel, Potter-Typer-Martin & Roth, on the architect's view of the place of lighting in school construction; Val McClusky, General Electric Co., on the need for the IES recommended levels of school lighting; and John Seeman, assistant superintendent of the Princeton Board of Education. Following the lecture program were demonstrations of the quality and quantity considerations influencing the design of a lighting system and the method for selection of the proper color of light for a particular area.

The meeting ended with a tour of the Princeton High School, including the lighted athletic field.

AIEE To Sponsor 1962 Electrical Engineering Show

Plans for an Electrical Engineering Exposition, to be held January 29 through February 2, 1962 at the New York City Coliseum, have been announced by Nelson Hibshman, executive secretary of the sponsoring American Institute of Electrical Engineers. The exposition will be held in conjunction with the Annual AIEE Winter General Meeting.

The decision to conduct the exposition was made as a result of a survey of AIEE members at last year's Winter General Meeting. Over 57 per cent of the members polled indicated a desire for exhibits of electrical products and servto transducers as well as other photoelectric devices.

Technical sessions of the 1962 Winter General Meeting will be held at the Coli-

SPEAKERS at Ohio Valley Section's successful School Lighting Symposium included, l. to r., photo at left: Val McClusky, General Electric Co.; John Seeman, assistant superintendent, Princeton, Ohio Board of Education; Harold J. Gruber, chairman, Ohio Valley Section; James E. Kneisel, architect. In photo at right, Warren Pence (left), Cincinnati Gas and Electric Co., demonstrates footcandle test box to a Symposium visitor. "Quality and Quantity" and color boxes were also used to demonstrate the need for scientifically-designed illumination systems.

Here and There With IES Members

Fair Exchange. Bob Zahour (left), first chairman of the New Jersey Section, now Northeastern Regional Vice-President, receives past chairman's pin from 1960-1961 New Jersey Chairman, Bill Till, while he presents Mr. Till with a check for the Section's first place standing in the Northeastern Region's membership campaign.

New members in the Western New York Section, shown here with Great Lakes Regional Vice-President, Alston Rodgers (third from right), are, left to right: Eugene Kaczor, Donald Scheu, Peter Busch, William Travers (Mr. Rodgers), Raymond Measer and Richard Fairbanks. Mr. Rodgers holds the "ever-burning lamp of knowledge," a memento of his talk at the Section's December meeting.

Architects, engineers and business leaders in the New Orleans vicinity learned the "New Facts of Light" from IES President Richard G. Slauer (second from right, photo at left) and Technical Director C. L. Crouch (right) at a meeting sponsored by the New Orleans Public Service Co., Louisiana Power and Light Co. and New Orleans Section of IES. Other speakers included, l. to r., photo at left: Gerald L. Andrus, president, New Orleans Public Service; C. Clifford Rawls, president, Louisiana Power and Light; (photo at right) G. J. Schroeder, chairman, New Orleans Section; C. J. Sinnott, New Orleans Public Service, chairman of meeting; C. L. Osterberger, Louisiana Power and Light. The meeting, held at the Royal Orleans Hotel, was attended by 300 people.

Installations in the News . . .

Lighting Channels Department Store Traffic

In addition to supplying 100 footcandles of comfortable illumination on the merchandise displays, the lighting system designed for The House of Jaffe department store, Butler, Pa., acts as a traffic director, leading customers to elevators and exits to reduce the congestion and confusion in the first floor sales area. Photo at left shows fluorescent coves, mounted across the ceiling at right angles to the aisles, combined with ceiling recessed incandescent units, creating a path of light to lead customers to elevators at the rear of the store. Large area fluorescent units with egg-crate louver shielding and fluorescent valances along the side wall (photo at right) lead shoppers leaving the elevators to the exits in the least crowded part of the store.

Photos and data are courtesy of William Roll, West Penn Power Co., Cabin Hill, Greensburg, Pa.

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seum and the Hotel Statler, joint headquarters for the event.

The Reber-Friel Co., Philadelphia exhibit management firm, has been retained to manage the exposition. Floor plans and detailed information now in preparation are available to interested companies from Reber-Friel, 117 S. 17th St., Philadelphia 3, Pa.

$4 Billion Invested in R&D By U. S. Electrical Industry

The electrical industry's $4 billion investment in research and development during 1960 was greater than that of all other United States industries combined. The announcement of this expenditure formed the background for reports on the dividends of some recent research, presented to a group of management executives at the 34th Annual Meeting of the National Electrical Manufacturers Association in New York City.

Lighting advances, through materials research, as reported by Dr. Herbert Trotter, Jr., president of General Telephone and Electronics Laboratories, included improvements in fluorescent lamp color and efficiency, development of electroluminescence and advances in photographic flashbulbs. Other speakers discussed progress in direct methods of power generation and structural materials, as a result of research, and the reasons for the shift of the center of scientific research from the campus to the industrial laboratory.

Wakefield Plans Merger With Abrasive & Metal Products, Detroit

The Wakefield Co., Vermilion, Ohio, has announced plans for a merger with Abrasive & Metal Products Co. of Detroit, manufacturers of abrasives and grinding wheels for industry. The plan which was announced by president A. F. Wakefield, subject to stockholder approval, will provide for the diversification of products with assets available for expansion through the acquisition of companies in related or other fields.

The name of the new company will be Wakefield Corp., with headquarters in Detroit. No change is planned in the personnel or policies of the Vermilion operation. T. D. Wakefield, executive vice-president of the present Wakefield Co. will be vice-president in charge of the electrical group of the new Wakefield Corp. which will include the Vermilion activities.

Officers of the new corporation will be A. F. Wakefield, chairman; S. J. Menzel, Detroit, president; T. D. Wakefield, executive vice-president, electrical group; Paul J. Brown, Detroit, executive vice-president, abrasives group; J. M. Surbrook, Detroit, vice-president, finance, treasurer and comptroller; Harold Olson, Detroit, secretary. Executive committee includes Messrs. Menzel, T. D. Wakefield and J. O. Kamm, president of Cleveland Quarries and a director of the present Wakefield Co.

No date has been set for vote of the Wakefield shareholders on the proposed merger, which has been approved by the directors of both companies.

Plastics in Building Exhibit To Travel Under SPE Sponsorship

A traveling educational and technical exhibit developed around the theme of "Plastics—A New Dimension in Buildings," has been organized by the Plastics in Building Professional Activity Group of the Society of Plastics Engineers, under the chairmanship of Armand G. Winfield. Scheduled to open in Springfield, Mass. on April 15, the exhibit will travel to some 16 major North American cities for month-long showings during 1961-1963.

The educational part of the exhibit, to be shown in museums and universities, is designed to bring technical information to architects, builders, contractors, interior designers and students in these fields. The technical display, composed of 30 individual units demonstrating plastic materials and designed and integrated products available for use in buildings, is divided into four major areas—background and introduction, constructural, interior furnishings and decorative and esthetic uses. The best uses of existing materials, as well as projected ideas for future uses will be on display.

Accompanying the opening of the exhibit in Springfield, the Western New England Section of SPE and the Plastics in Buildings committee are sponsoring a one-day technical conference on April 20.

Some two dozen companies are serving as co-sponsors for the exhibit which is scheduled to visit New York, Washington, Minneapolis, Dallas, Seattle, Los Angeles, Birmingham, Memphis, Columbus and Toronto.

G-E Institute Offers Wide Range of Lighting Courses

The General Electric Lighting Institute at Nela Park, Cleveland, Ohio, has announced the 1961 schedule of its annual series of lighting education programs. The schedule of lectures and demonstrations includes several four-day advanced lighting conferences on commercial/industrial and residential application, as well as fundamentals courses and conferences designed to keep members of allied fields informed on the latest lighting developments.

Dates and subjects include:

February 20-23—Advanced Commercial and Industrial Applications.
March 1-3—Advanced Residential Conference for Academy of Lighting Arts Graduates.
March 6-8—Electrical Contractors.
March 8-10—Architects and Consulting Engineers.
March 13-17—Commercial and Industrial Fundamentals.
April 5-7—Advanced Residential Applications.
April 10-11—Industrial Executives and Engineers.
April 17—School Lighting.
May 3-4—Basic Course on Light for Living, for lighting service personnel, distributors, residential designers, electrical contractors.
May 8-11—Advanced Commercial and Industrial Applications.
May 22-26—Commercial and Industrial Fundamentals.
June 14-16—New Development Seminar—Commercial and Industrial Applications.
June 21-23—Architects and Consulting Engineers.
September 6-7—Industrial Power Salesman.
September 11—School Lighting.
September 13-15—Adanced Residential Applications.
October 2-6—Commercial and Industrial Fundamentals.
October 9-10—Electrical Contractors.
October 12—Office Lighting.
October 18-20—Architects and Consulting Engineers.
October 23-24—Industrial Executives and Engineers.
October 25-26—Utility Commercial Salesmen.
November 1-2—Basic Course on Light for Living.
November 13-16—Advanced Commercial and Industrial Applications.
December 1—Home Builders Lighting Design Clinic.
December 11-15—Commercial and Industrial Fundamentals.

Detailed program information and registrations may be made through the local G-E Lamp Sales District Offices.

E. W. Commery Library Donated to Miami University

The illumination and color library of the late Eugene W. Commery has been presented to the University of Miami Libraries. George Gill, chairman of the Southeast Florida Section, made the presentation on behalf of Mrs. Commery.

IES MEMBER, Robert S. Wiseman (right), receives "Outstanding" rating certificate for his work as chief of the Warfare Vision Branch of the U. S. Army Engineer Research and Development Laboratories, Ft. Belvoir, Va., from Col. John H. Kerkering, director of the Laboratories. Dr. Wiseman had previously received a "Sustained Superior Performance" award.

Mr. Commery, who died on May 25, 1960 at the age of 66, was an IES Fellow and internationally known residential lighting expert. His professional career, spent entirely with the General Electric Lamp Division, culminated in the position of residential lighting supervisor.

Following his retirement in 1958, Mr. Commery moved to Key Biscayne, Fla., where he was active as a speaker, lighting consultant and member of the IES Southeast Florida Section.

Electric Utilities Plan Exhibit for '64 World's Fair

A new corporation, Power & Light Exhibit, Inc., has been organized by the public electric utility companies to handle the industry's participation in the 1964-65 New York World's Fair. The company has already selected a 44,000 square foot exhibit space and retained VEK Associates, Inc., to develop architectural plans, theme, exhibits and programming for the display.

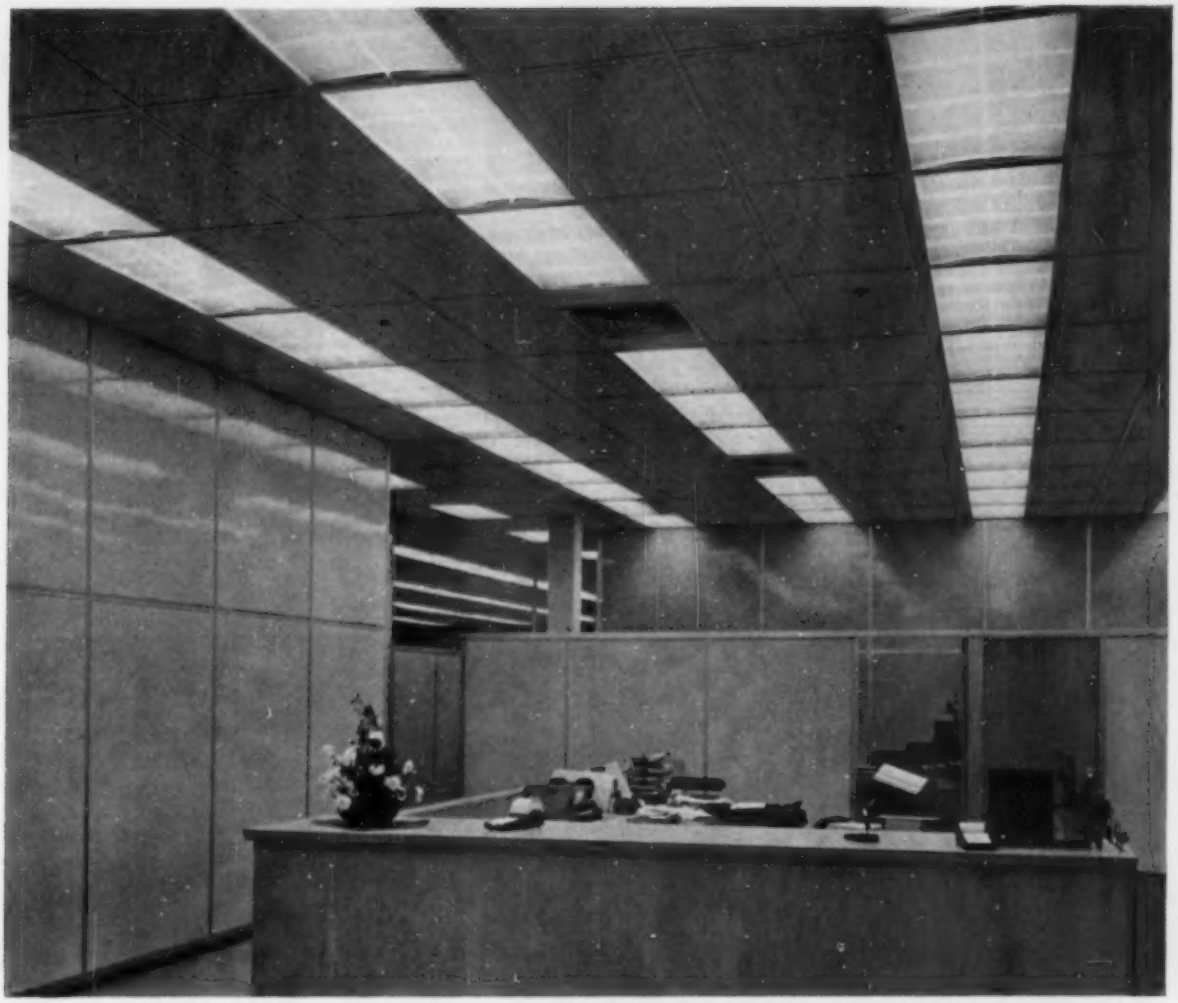
Ernest R. Acker, chairman of the board of Central Hudson Gas & Electric Corp., was named president of Power & Light Exhibit, Inc. Mr. Acker is also chairman of the Edison Electric Institute World's Fair Committee. Other officers of the new corporation include: vice-president, Edwin Vennard, managing director, EEI; secretary, G. F. Landrith; treasurer, H. S. Sutton, treasurer, Consolidated Edison Co. of New York; as-

(*Continued on page* 12A)

Watch for Innovations in March IE

March IE, due on members' desks about March 15, will be in two separate parts. Part II will consist entirely of application engineering articles, practical current lighting application information, news (including several new departments) and advertising. Part I will contain, all together, fourteen of the 1960 National Technical Conference papers, along with full discussion.

This innovation in the Society's publications program is taken as another step in improved service to members through ILLUMINATING ENGINEERING. The early publication, within one cover, of a large percentage of the Conference papers is expected to open up the pages of subsequent issues of IE to an increased volume of timely lighting application articles and items of current interest to a larger number of members.



2' x 2' control lenses of PLEXIGLAS *mounted in pairs, County of Sonoma office building, office of Superintendent of Schools, Santa Rosa, California • Architects: Steel & Van Dyke, Santa Rosa*

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PLEXIGLAS

(*Continued from page 10A*)

sistant treasurer, C. R. Bozek. In addition, the public utility executives who are members of the EEI World's Fair Committee are serving on the board of Power & Light Exhibit, Inc.

VEK Associates, Inc., an alliance of Vandeburg-Linkletter Associates, Ebasco Services and Walter Kidde Constructors, was organized to handle the planning of all exhibits at the Fair.

C. W. Macy Retires Spent 32 Years with PG & E

C. W. (Chic) Macy retired from the Pacific Gas & Electric Co. in San Francisco on February 1. He had been associated with the company since 1928, and held the position of commercial-industrial lighting sales supervisor for the past 18 years.

One of the most active IES members on the West Coast, Mr. Macy has been South Pacific Coast Regional Program Chairman for the past three years. He is credited with the development of the regional speaker circuit plan which arranges to bring noted speakers to the West Coast for a planned tour of all of the Society's Sections and Chapters in the area.

Mr. Macy was chairman of the Golden Gate Section in 1957-1958, secretary in 1955-1956, and a member of the Conference Executive Committee for the 1959 IES National Technical Conference in San Francisco. In addition, he has been a member of the Office Lighting Committee and several of its subcommittees for many years.

C. W. Macy

In 1940, Mr. Macy joined IES as an associate member, transferring to Member grade in 1946. He attended the Ecole de Commerce in Toulouse, France.

Installations in the News . . .

High-Level Lighting Aids Plant Growth Research

Although scientists do not yet know how much light is required for optimum plant growth, plants grown under a 5000-footcandle lighting installation at the U. S. Department of Agriculture Research Center in Beltsville, Md., are superior to those grown under lower-level lighting. The installation of 64 eight-foot, 1500-ma fluorescent lamps, supplemented by forty 100-watt incandescent lamps, which blanket the ceiling in a 9-by 16-foot room, is also credited with having contributed to the discovery of a growth-controlling, light-sensitive substance found in all plants—two forms of a blue pigment which act as valves opening or closing according to the kind of light received.

The presence of this growth-controlling compound was determined during research on the effects of different colors of light on plant growth. Red light has been found to prevent flowering in some plants, promote it in others, and promote seed germination and production of red coloring in plant parts.

The length of time plants are exposed to light also influences their growth. Some plants require long periods of light for flowering, while others flower only after prolonged periods of darkness. These research findings have aided in the scientific selection of optimum crops for particular areas.

Photo and data courtesy of General Electric Co., Cleveland, Ohio.

ABOUT PEOPLE

(A), (M) and (F) indicate Associate Member, Member and Fellow grade in the Society.

J. Stanford Smith, General Electric Co., Hendersonville, N. C., has been elected chairman of the Street Lighting Section of the National Electrical Manufacturers Association. Mr. Smith succeeds **E. B. Karns** (M), Westinghouse Electric Corp., Cleveland, Ohio. **F. A. Rudolph,** president of the Ripley Co., Inc., Middletown, Conn., has been named vice chairman, and **K. C. Dorland** (A), The Union Metal Manufacturing Co., Canton, Ohio, has been elected to represent the Section on the board of directors of the NEMA Lighting Equipment Division.

A committee of seven executives has been appointed to guide the newly established Research Division of the Edison Electric Institute, according to an announcement by EEI president Sherman R. Knapp. Chairman of the Research Division Executive Committee is **Willis Gale,** chairman of the Commonwealth Edison Co., Chicago, Ill. Members are **P. A. Fleger,** chairman of the board and president, Duquesne Light Co., Pittsburgh, Pa.; **R. A. Gibson,** president of The Hartford Electric Light Co., Hartford, Conn.; **J. K. Horton,** president of the Southern California Edison Co., Los Angeles, Calif.; **D. C. Luce,** president, Public Service Electric and Gas Co.,

(*Continued on page 14A*)

Photographed in the offices of Lawrence W. Hornfeck, Consulting Electrical Engineer, Pittsburgh, Pa.

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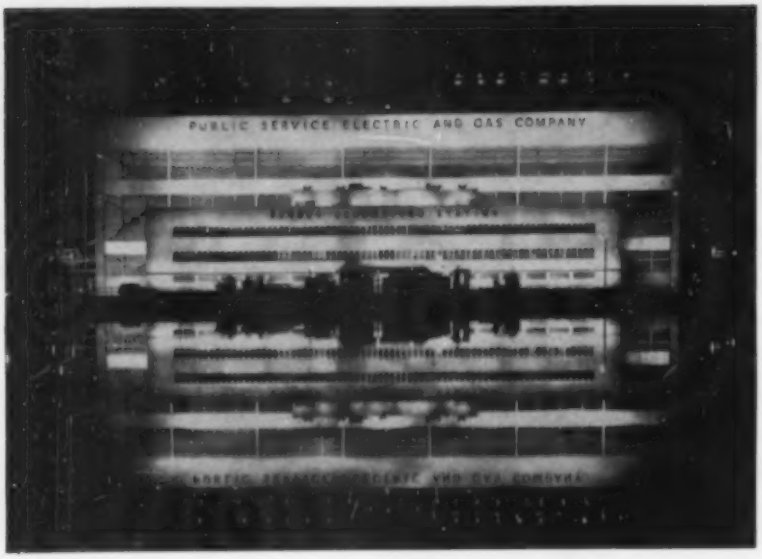
Installations in the News . . .



Generating Station Becomes New Jersey Landmark

Viewed from the New Jersey Turnpike, the floodlighted $110 million Bergen Generating Station of the Public Service Electric and Gas Co. at Ridgefield, N. J. is a spectacular sight. The administration building and turbine room, mirrored in Overpeck Creek between the plant and the Turnpike, are lighted by 136 luminaires, including 96 400-watt mercury units.

Lighting levels are 14 footcandles on the turbine room wall, 10 footcandles on administration building. The station's generating capacity is 580,000 kilowatts.

Photo and data courtesy of General Electric Co., Schenectady, N. Y.

(Continued from page 12A)

Newark, N. J.; **W. W. Lynch,** chairman of the board and president, Texas Power & Light Co., Dallas, Texas; **W. O. Turner,** chairman of the board, Louisiana Power & Light Co., New Orleans, La. The new division will utilize the Institute's Research Projects Committee, formed nine years ago, which recently made recommendations leading to the establishment of the Research Division.

The election of **Harold Massey,** managing director of the Gas Appliance Manufacturers Association, as chairman of the Standards Council of the American Standards Association for a one-year term which began January 1, 1961, has been announced by ASA. Mr. Massey replaces **T. E. Veltfort,** Copper and Brass Research Association, who served as chairman from 1958 to 1960. Also elected was **E. O. Mattocks,** American Petroleum Institute, who will serve as vice chairman. The Standards Council has the ultimate responsibility for guiding the voluntary national standards program being conducted under the Association's procedures for standardization.

L. C. Diekmann has been named director of manufacturing for the consumer products group of the Westinghouse Electric Corp. Mr. Diekmann will serve in a consulting capacity on all manufacturing matters for the divisions within the group, including the lamp division in Bloomfield, N. J.

Deane B. Judd, National Bureau of Standards, has been named editor of the *Journal of the Optical Society of America.* Mr. Judd, a color expert, replaces **Wallace R. Brode** who has accepted an appointment as science advisor to the new Secretary of State, Dean Rusk.

The appointment of **William B. Maley** as director of development has been announced by Trans-Lite, Inc., Milford, Conn. Formerly associated with the Reliance Electric and Engineering Co., Cleveland, Ohio, Mr. Maley's new responsibilities include the determination and evaluation of new products and markets.

Leonard V. James (F) has resigned as a consultant to the Solar Light Manufacturing Co., Chicago, Ill., to make his home in Scarsdale, N. Y. Mr. James, who became an illuminating engineering consultant after his retirement from the General Electric Co. in 1949, was associated with Solar for six years.

Deaths

W. H. Alexander, American Sterilizer Co., Erie, Pa.
W. J. Beran, San Diego Section
C. F. Davis, Southern California Section
Adolph Fremder, St. Louis Section
C. S. Leopold, Philadelphia Section
J. B. O'Donnell, Milwaukee Section
W. L. Parish, Iowa Section
A. M. Rosenblatt, New York Section
R. D. Scribner, Northumberland Section
B. C. Vawter, Ohio Valley Section
K. R. Wolfe, Philadelphia Section
Philip Young, New York Section

BOOKS AND PAMPHLETS

Guide for Planning and Operating Church Kitchens, published by the Edison Electric Institute, 750 Third Ave., New York 17, N. Y., 26 pp.

Designed as a practical guide for church groups whose building programs contain plans for kitchen facilities, this publication includes a summary of the various aspects of electric cooking.

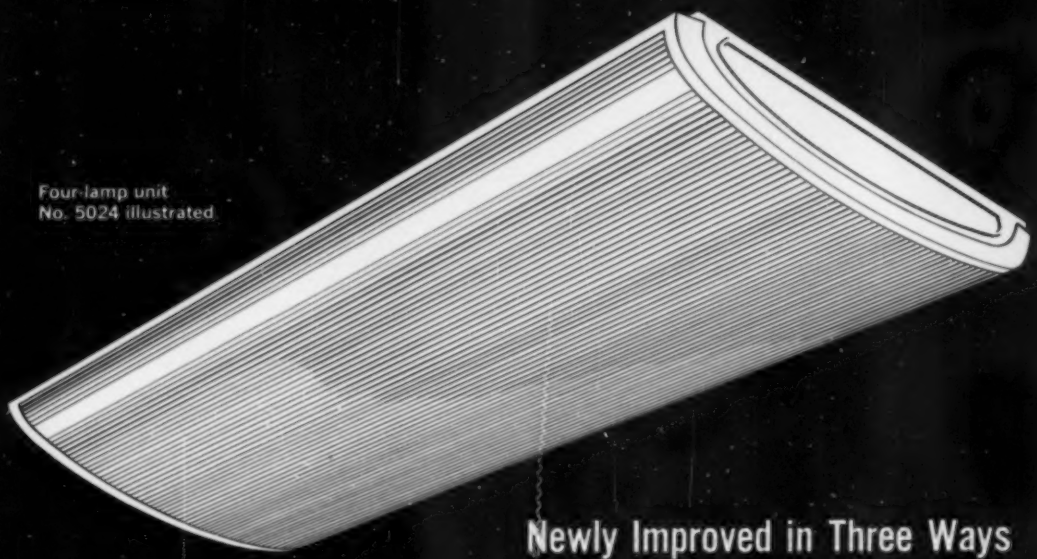
Prices are $22.50 per 100 copies, plus 10 per cent to nonmembers of EEI. Orders should be sent to the Sales Division, Edison Electric Institute, at the above address.

Salaries and Income of Engineering Teachers—1960, available from Engineering Manpower Commission, 29 West 39th St., New York 18, N. Y. 25 cents.

Results of a survey of the income of over 5000 engineering teachers (more than half the total number) reported in this publication indicate that their income has risen 14.7 per cent over the past two years. The survey was conducted by the American Society for Engineering Education under a grant from the National Science Foundation.

Report of the survey results, prepared by Morris A. Horowitz of the Bureau of

(Continued on page 19A)



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NEW CHOICE OF DIFFUSERS. A Garcy first . . . Owens-Corning's polarizing Fiberglas in a curved panel. In milk-white diffusers, our Koppers Even-Glo polystyrene and Plexiglas acrylic are the finest available.

NEW SURFACE BRIGHTNESS CONTROL. A slight alteration in the relationship of the diffuser to the lamps has completely eliminated shadows and lamp images, resulting in uniformly soft surface brightness across the entire panel.

NEW STYLING. The shallow, ceiling-hugging design that gives Ultra-Lux its "built-in look" is unchanged but the end has been re-styled for a cleaner, trimmer appearance.

The Ultra-Lux is available 12" wide (two-lamp 4 ft. or 8 ft.) and 24" wide (four-lamp 4 ft.) as shown above.

Send for newly published Bulletin 60-C

GARCY LIGHTING

Div. of Garden City Plating & Mfg. Co.
2475 Elston Avenue • Chicago 47, Ill.

EXPLOSION-PROOF

Killark explosion-proof light fixtures provide approved protection for Class 1, Groups C and D; Class 2, Groups E, F, G installations. Special inner reflector plays important part in excellent lighting efficiency. Pendant, ceiling, bracket and flush mountings. Shock-proof, heat-resistant annealed globe. 60 to 500 watt.

DUST-TIGHT

Approved light fixtures for use in Class 2, Groups E, F, G hazardous locations. Vertical design keeps dust from accumulating, close fitting parts keep it from entering fixture. Coolest burning dust-tight lights mean added safety. 100 and 150-300 watt sizes.

SPECIAL LOCATIONS

Conch light
Many applications—indoors or outdoors. Attractive fleur-de-lis design. With or without switch.

Flood light
Weather proof in any position. Styles for PAR-56 and PAR-64 sealed beam lamps.

Sealed beam light
Variety of single or cluster styles, adjustable mountings. Sealed against weather. PAR-38 and R-40 lamp styles.

Louver light
For steps, passageways, small signs. Easily installed and serviced.

Mushroom island light
Basic island light, plus one to five sealed beam spot lights, as required. Ideal for service stations, parking lots, etc.

Dekorative light
Gives added beauty. Pendant or ceiling-mounting, frosted or clear globe. 60, 100 and 150 watt lamps.

Killark

ELECTRIC MANUFACTURING CO.

Vandeventer and Easton Ave. • St. Louis, Missouri

In Canada: Killark Electric of Canada, Ltd., 421 Islington Ave. South, Toronto 18, Ont.

VAPOR-TIGHT

The Killark line has vapor-tight light fixtures for every outdoor or indoor need. Design simplicity and interchangeable parts makes these lights easy to install and service. Positively weather-proof. Pendant, ceiling, bracket mountings. 60 to 500 watt.

ACCESSORIES

Write for the Killark lighting catalogs..

Wherever protected illumination is needed...

KILLARK LIGHT FIXTURES SERVE WITH DEPENDABILITY

A complete line of industrial and commercial lighting fixtures allows Killark to serve all types of installations with proper protected lighting. The Killark ability to supply exact needs means maximum safety, convenience, and efficiency—for both hazardous and non-hazardous locations.

All Killark fixtures are cast from aluminum to provide important extra advantages. Installed inside or outdoors, they remain permanently rust-proof. They give outstanding service in many areas where corrosion is a problem. Aluminum also dissipates heat at a much faster rate, and is safer because it's non-sparking.

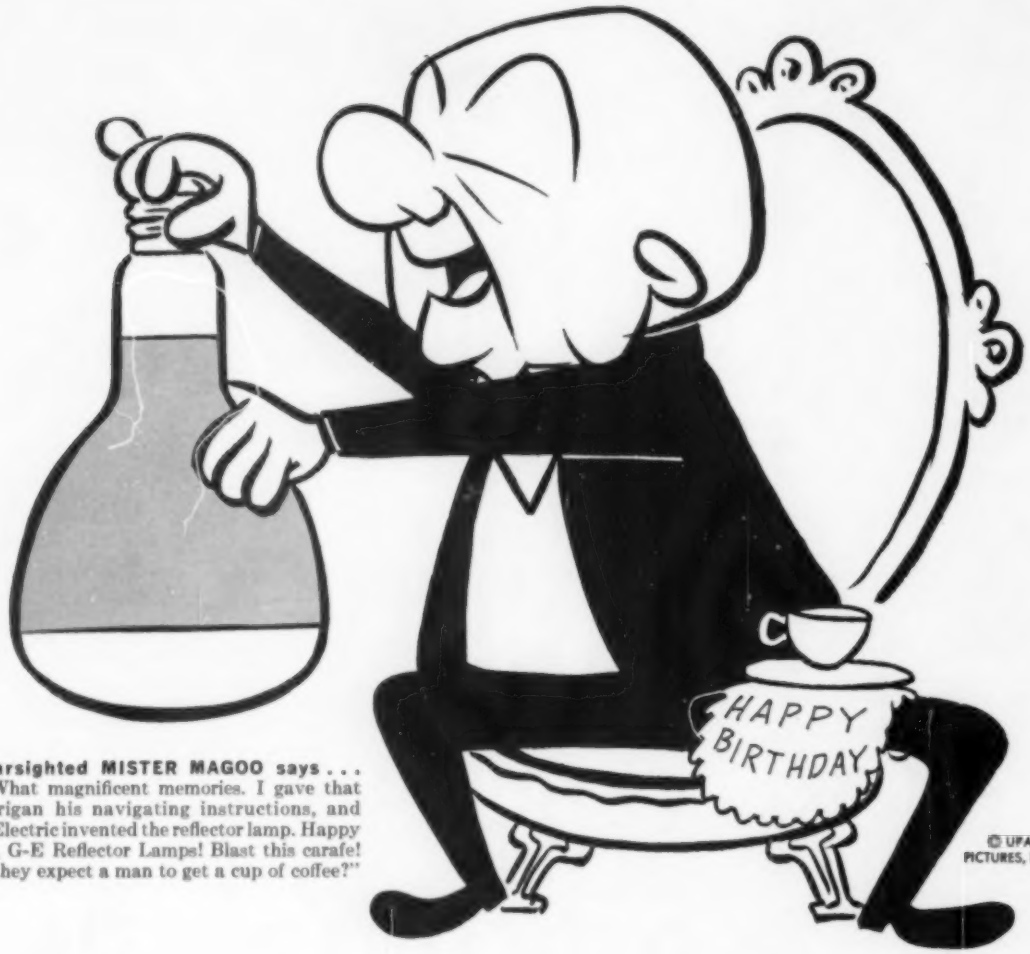
Simplicity of design is still another reason for the superior performance of Killark light fixtures. Most styles have interchangeable parts to allow quick, inexpensive changes in mounting method, wattage capacity, type of globe, or reflector. Relamping can be done easily without tools.

Your Killark dealer can supply these fine light fixtures promptly—from his stock or one of the nineteen Killark warehouses in the United States and Canada.

Killark light fixtures are U.L. and C.S.A. approved.

SOLD THROUGH WHOLESALERS FROM COAST TO COAST AND IN CANADA. WAREHOUSE STOCKS IN NINETEEN CITIES.

6025



The nearsighted MISTER MAGOO says . . . "1938? What magnificent memories. I gave that boy Corrigan his navigating instructions, and General Electric invented the reflector lamp. Happy birthday, G-E Reflector Lamps! Blast this carafe! How do they expect a man to get a cup of coffee?"

© UPA PICTURES, INC.

General Electric Reflector Lamps laugh off dirt and dust— send more light where it's needed

Now your customers can cut maintenance costs—*and get more light overnight*—without spending a penny for new equipment or increasing their power costs.

How? Switch them to General Electric Reflector Lamps for their filament or mercury lamp systems.

A pure silver reflector (or phosphor in mercury lamps) is sealed inside a specially shaped bulb where it can't get dirty. It directs more light *down* on the job—day in, day out. Customers get all the light they pay for. Employees get more light, can do better work faster.

Maintenance men seldom, if ever, have to clean fixtures. All they do is change burnouts—and the long, uniform life of G-E Lamps means changing can be done on a regular schedule.

General Electric *Filament* Reflector Lamps (developed in 1938) are available in 500-W, 750-W and 1000-W sizes with pure silver reflectors (above). G-E *Mercury* Reflector Lamps (1952) come in 400-W (silver or phosphor reflectors), and 1000-W (phosphor reflector) sizes. Your General Electric Lamp distributor can help you pick the best one to recommend. Call him today. General Electric Co., Large Lamp Dept. C-12, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

(Continued from page 14A)

Business and Economic Research, Northeastern University, Boston, is an adjunct to a more comprehensive survey of professional income of *all* engineers, scheduled for publication later this year.

1960 Bibliography for Office Management, published by National Office Management Association, Willow Grove, Pa. 74 pp., $5.00.

References to over 550 magazine articles and 70 books in the field of office management published between May, 1959 and April, 1960, are contained in the 16th annual edition of this bibliography. The compilation is in three sections—articles, booklets and reports, books and films—with a listing of publishers preceding each section.

American Standard Drafting Manual, Section 15, Electrical Diagrams, Y14.15-1960, available from American Standards Association, 10 East 40th St., New York 16, N. Y. Price: $1.50.

Definitions and general information applicable to most of the commonly used electrical diagrams and recommendations on preferred practices for use in the preparation of these diagrams are contained in this manual. The data in the standard pertain to electrical diagrams of the type used by the electronics and communications industries.

Directory of National Associations of Businessmen: 1960, available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price: 50 cents.

Societies of engineers and scientists, in addition to trade associations, are listed in this U. S. Department of Commerce publication. Data on some 2,000 national organizations include number of members, size of staff, name and title of chief executive, year organized and mailing address.

Orders may also be submitted to Department of Commerce Field Offices.

The Road to Graduate School, published by the American Society for Engineering Education, 20 pp. No charge for undergraduate engineering students.

Prepared by students in the University of Illinois chapter of Tau Beta Pi, engineering honorary society, the booklet aims at presenting an objective description of graduate study at any accredited engineering school in the United States. Academic, financial and social considera-

(Continued on page 22A)

SCHEDULED EVENTS

1961 Dates of Interest to IES Members

February

February 19-22—National Electric Sign Association Convention, Benjamin Franklin Hotel, Philadelphia, Pa.

March

March 2-4—Optical Society of America, Roosevelt Hotel, Pittsburgh, Pa.

March 5-8—Third National Lighting Exposition and World Lighting Forum, New York City Coliseum, New York, N. Y.

March 8-9—National Association of Lighting Maintenance Contractors, Central Regional Meeting, Cleveland, Ohio

March 20-23—Edison Electric Institute, Annual Sales Conference, Edgewater Beach Hotel, Chicago, Ill.

March 21-23—American Power Conference, sponsored by Illinois Institute of Technology, Sherman Hotel, Chicago, Ill.

April

April 8-15—Electrical Home Show, War Memorial Building, Rochester, N. Y.

April 10-11—East Central Regional Conference, IES, Benjamin Franklin Hotel, Philadelphia, Pa.

April 10-12—Inter-Society Color Council, Annual Meeting, Sheraton Hotel, Rochester, N. Y.

April 17-18—Southwestern Regional Conference, IES, Skirvin Hotel, Oklahoma City, Okla.

April 20-21—Southeastern/South Central Regional Conference, IES, Biltmore Hotel, Atlanta, Ga.

April 23-28—American Institute of Architects, Annual Convention, Philadelphia, Pa.

April 29-May 3—National Association of Electrical Distributors, Annual Convention, Detroit, Mich.

April 30-May 4—Electrochemical Society Meeting, Claypool Hotel, Indianapolis, Ind.

May

May 1-2—Intermountain Regional Conference, IES, Salt Lake City, Utah.

May 1-3—American Institute of Electrical Engineers, Rural Electrification Conference, Kentucky Hotel, Louisville, Ky.

May 2-4—Electric Association of Chicago, Sixth Biennial Midwest Electrical Industry and Lighting Exposition, McCormick Place, Chicago, Ill.

May 4-5—South Pacific Coast Regional Conference, IES, Sacramento Inn, Sacramento, Calif.

May 8-9—Pacific Northwest Regional Conference, IES, Harrison Hot Springs, Harrison, B. C.

May 15-16—Canadian Regional Conference, IES, Queen Elizabeth Hotel, Montreal, Que.

May 15-17—Building Research Institute Conference, Shoreham Hotel, Washington, D. C.

May 22-25—Design Engineering Show, Cobo Hall, Detroit, Mich.

June

June 2-3—Maritime IES Conference, Moncton, N. B.

June 5-7—Edison Electric Institute, Annual Convention, New York, N. Y.

June 5-9—Society of the Plastics Industry, National Conference, Commodore Hotel, New York, N. Y.

June 7—IES Council Meeting, Barbizon Plaza Hotel, New York, N. Y. Members are invited to attend meetings as guests of Council.

June 8-9—Northeastern Regional Conference, IES, Berkeley-Carteret Hotel, Asbury Park, N. J.

June 18-23—American Institute of Electrical Engineers, Summer General Meeting, Ithaca, N. Y.

June 19-20—Great Lakes Regional Conference, IES, Sheraton-Gibson Hotel, Cincinnati, Ohio.

June 23-28—American Society of Heating, Refrigerating and Air Conditioning Engineers, Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

July

July 4-7—National Society of Professional Engineers, Annual Meeting, Olympic Hotel, Seattle, Wash.

July 18-20—Western Plant Maintenance Show, Pan Pacific Auditorium, Los Angeles, Calif.

August

August 21-23—National Association of Lighting Maintenance Contractors, National Convention, Flamingo Hotel, Las Vegas, Nev.

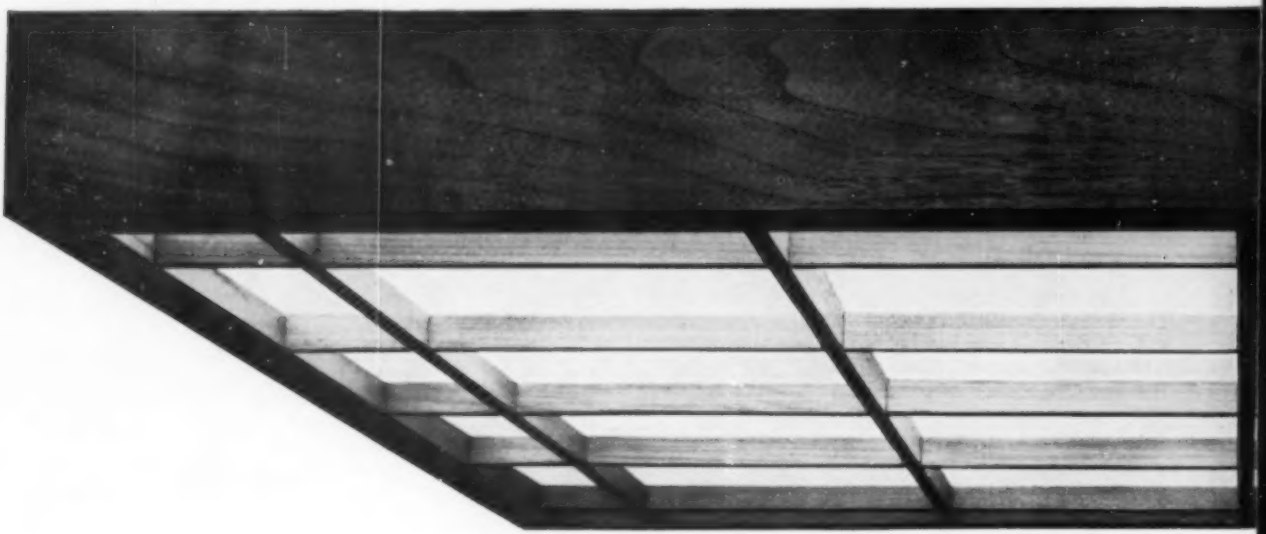
September

September 14-15—Engineering Management Meeting, sponsored by AIEE and ASME, Hotel Roosevelt, New York, N. Y.

September 24-29—Illuminating Engineering Society, National Technical Conference, Chase-Park Plaza Hotel, St. Louis, Mo.

This is the embodiment of a design philosophy...a blending of function with aesthetics ...an imaginative application of appropriate materials to good lighting. The product is *Corona,* an appealing new treatment for fluorescents that transforms them into an effective decorative element. A wonderfully warm walnut frame surrounds the diffusing pane, while handsome birch

NEW! FLUORESCENTS



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Jersey City 5, New Jersey Showrooms: New York, Chicago, Dallas, Los Angeles

Corona is stocked by these Authorized LIGHTOLIER Distributors:

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W. T. Foley Elec. Co.
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Louisville:
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NEW YORK
Binghamton:
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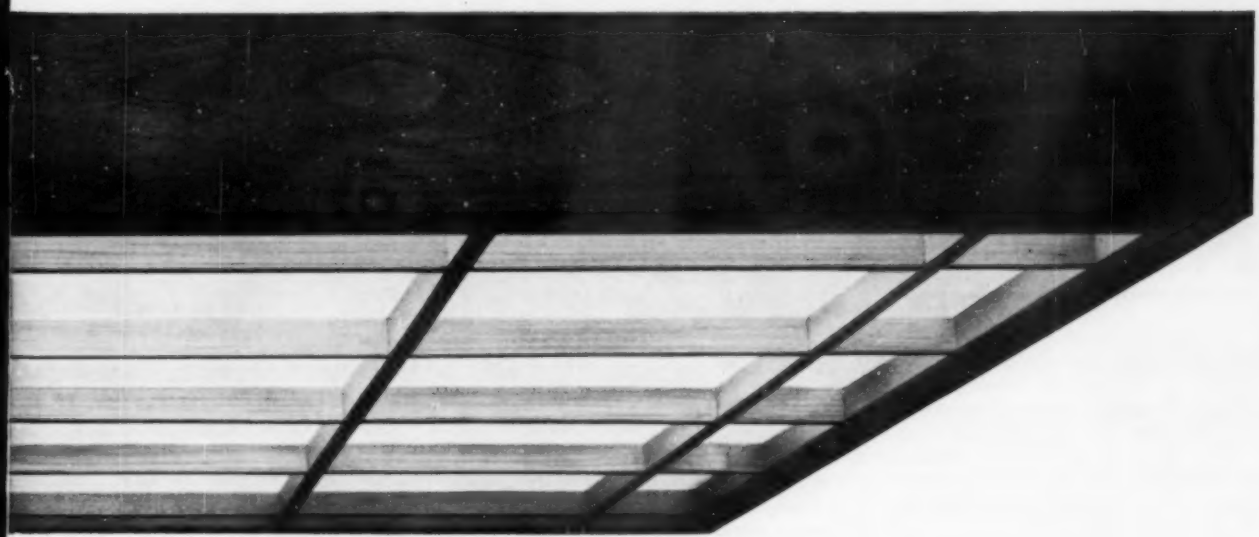
Buffalo:
Buffalo Incand. Light Co. Inc.
Niagara Falls:
Hysen Supplies Inc.

baffles cut a pleasing modular pattern across its surface. The feeling is one of warmth and friendly informality . . . contemporary in styling, yet completely harmonious with traditional decor, residential as well as commercial. Optically, *Corona* is all that one might expect from a fine lighting instrument engineered by Lightolier. In four sizes: 54″ x 54″, 30″ x 30″, 32″ x 54″, 16″ x 54″.

FRAMED IN FINE WOOD



To learn more about Corona and other surface and pendant fixtures, write today for a complete brochure to Dept. IE-2

LIGHTOLIER®

...for a better way of Light

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Rochester: Rowe Electric Sup. Co.
Syracuse: Superior Elec. Corp.

NORTH CAROLINA
Charlotte: Independent Elec. Sup. Co.
Durham: Noland Co.
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Kinston: Kinston Elec.
Winston Salem: Noland Co.

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Toledo: Gross Elec. Fix. Co.
Youngstown: Mart Industries
The Braff Ltg. Fix. Co.

OKLAHOMA
Oklahoma City: Elec. Sup. of Oklahoma

OREGON
Portland: Baker-Barker Co.

PENNSYLVANIA
Allentown: Coleman Elec. Co.
Erie: Kraus Elec. Co.
Harrisburg: Fluorescent Sup. Co.
Hazleton: Power Elec. Co. Inc.
New Castle: Midwestern Elec. Co.
Philadelphia: Ace Lighting Fix. Co.
Gold Seal Elec. Sup. Co.
Sylvan Elec. Fix. Co.
Pittsburgh: Allied Elec. Sup. Co.
Argo Lite Studios
Brown & Green
Wally Elec. Sup. Co.
Reading: Coleman Elec. Co.
Scranton: Lewis & Reif, Inc.
Uniontown: Pioneer Electric Dist.
Wilkes Barre: Anthracite Elec.

RHODE ISLAND
Pawtucket: Major Elec. Sup. Co.
Providence: Leavitt Colson Co.

SOUTH CAROLINA
Columbia: Capitol Elec. Sup.
Noland Co.
Greenville: Sullivan Hdwe. Co.

SOUTH DAKOTA
Watertown: J. M. Larson Elec. Co.

TENNESSEE
Knoxville: Square Elec. Sup. Co.
Memphis: Belvedere Lighting Co.
Nashville: Nashville Elec. Sup. Co.

TEXAS
Dallas: Rogers Elec. Sup. Co.
Ft. Worth: Anderson Fixture Co.
Cummins Supply Co.
General Industrial Sup. Corp.
Houston: Gross Electric Supply
Gulf Coast Elec. Sup. Co. Inc.
Martin Associates
Southern Electric Supply Co.
Worth Elec. Sup. Co.
San Antonio: Southern Equip. Co.
Strauss-Frank Co.

UTAH
Salt Lake City Artistic Lighting

VIRGINIA
Arlington: Dominion Elec. Sup. Co. Inc.
Noland Co.
Lynchburg: Mid-State Elec. Sup. Co., Inc.
Norfolk: Noland Co.
Roanoke: Noland Co.

WEST VIRGINIA
Clarksburg: Talley Engineering Co.
Huntington: West Virginia Elec. Co.
Wheeling: The Front Co.

WISCONSIN
Appleton: Moe Northern Co.
Eau Claire: W. H. Hobbs Sup. Co.
La Crosse: W. A. Roosevelt Co.
Milwaukee: Electri-Craft Lighting
Lappon Electric Co.
Standard Elec. Sup.

WASHINGTON
Seattle: Seattle Lighting Fix. Co.

CANADA
Montreal: L. D. G. Products, Inc.
The Grey Elec. Co.
Union Electric Sup. Co. Ltd.
Toronto: Revere Elec. Dist.
Toronto Ltg. Studios

(*Continued from page* 19A)

tions are discussed from the undergraduate point of view.

Copies are available from engineering deans and individual chapters of Tau Beta Pi.

Glass—Integral Component of Quality Lighting, available from Lighting Sales Department, Corning Glass Works, Corning, N. Y. No charge.

Offered as an idea stimulator for architects, engineers, contractors and designers, this brochure illustrates the use of glass in several lighting installations. Also included are data on lighting panels and fixtures used in each installation.

NEW MEMBERS

At the meeting of the IES Council Executive Committee in New York City on January 12, 1961, the following were elected to membership. Names marked * are transfers from Associate Member Grade. Names marked ** are transfers from Student Member Grade. Names marked *** are transfers from Associate to Student Member Grade.

CANADIAN REGION

BLUENOSE CHAPTER

No Elections

FOREST CITY (LONDON) CHAPTER

No Elections

GOLDEN WEST CHAPTER

Associate Member:

Beuker, G. H., Saskatchewan Power Corp., Regina, Sask.

HAMILTON, ONTARIO CHAPTER

No Elections

MARITIME CHAPTER

No Elections

MONTREAL SECTION

Member:

Angus, F. W. R., McDougall & Friedman, Montreal, Que.

Associate Member:

Holoduke, S. P., Integrated Lighting Ltd., Montreal, Que.

NORTHUMBERLAND CHAPTER

No Elections

OTTAWA SECTION

Associate Member:

Pearce, J. K., Directorate of Works, Ottawa, Ont.

QUEBEC CHAPTER

No Elections

ST. MAURICE VALLEY CHAPTER

No Elections

TORONTO SECTION

Members:

*Blakely, H. C., Picton Utilities Commission, Picton, Ont.

Milner, J. H., Camera Lighting Services, Scarborough, Ont.

Widdifield, I. S., Ontario Hydro Electric Power Commission, Toronto, Ont.

Associate Members:

Christenson, E. V., Donovan Construction Co. of Canada Ltd., Toronto, Ont.

Day, R. V., Canadian General Electric Co. Ltd., Toronto, Ont.

WINNIPEG CHAPTER

No Elections

EAST CENTRAL REGION

CAPITAL SECTION

Member:

*Fox, A. A., Albert A. Fox Agency, Washington, D. C.

EASTERN PENNSYLVANIA SECTION

No Elections

MARYLAND SECTION

No Elections

PHILADELPHIA SECTION

Associate Members:

Manwaring, A. H., III, Philadelphia Electric & Manufacturing Co., Philadelphia, Pa.

McKinnon, C. H., Philadelphia Electric Co., Philadelphia, Pa.

PITTSBURGH SECTION

Member:

*Doherty, W. J., General Electric Co., Pittsburgh, Pa.

(*Continued on page* 26A)

1961 IES Regional Conferences

Region	Date and Place	Chairman
East Central	April 10-11 Benjamin Franklin Hotel Philadelphia, Pa.	Ralph R. Enghouser Sylvania Electric Products 4700 Parkside Ave. Philadelphia, Pa.
Southwestern	April 17-18 Skirvin Hotel Oklahoma City, Okla.	Paul R. Sheline Paul R. Sheline Co. 1715 Linwood Blvd. Oklahoma City, Okla.
Southeastern/ South Central	April 20-21 Biltmore Hotel Atlanta, Ga.	Charles R. Minors Georgia Power Co. P. O. Box 1719 Atlanta, Ga.
Inter-Mountain	May 1-2 Salt Lake City, Utah	Donald Dyrenforth General Electric Co. 249 E. 5th South Salt Lake City, Utah Wayne F. Mulcock Utah Power & Light Co. P. O. Box 899 Salt Lake City, Utah
South Pacific Coast	May 4-5 Sacramento Inn Sacramento, Calif.	M. P. Fenton Smoot-Holman Co. 1331 T St. Sacramento, Calif.
Pacific Northwest	May 8-9 Harrison Hot Springs Harrison, B. C.	E. A. Adams Griffon Sales Ltd. 551 W. 8th Ave. Vancouver, B. C.
Canadian	May 15-16 Queen Elizabeth Hotel Montreal, Que.	J. P. Cristel Shawinigan Water & Power 600 Dorchester St. West Montreal, Que.
Northeastern	June 8-9 Berkeley-Carteret Hotel Asbury Park, N. J.	Bruce J. Jensen Public Service Electric & Gas Co. 80 Park Place Newark, N. J.
Great Lakes	June 19-20 Sheraton-Gibson Hotel Cincinnati, Ohio	H. K. Flint 2926 Debreck Ave. Cincinnati, Ohio

Careful attention to design and construction refinements characterize Revere's standard line. These same skills help answer the unusual equipment needs brought to Revere by volume users of specialized outdoor lighting products.

What makes Revere the consultant's choice for outdoor lighting?

Revere capacity gives you wider choice of standard equipment and excellent service on custom designs

You can solve the vast majority of outdoor lighting problems with the wide line of standard equipment listed in Revere's catalog. And for unusual application requirements, you can get prompt service on custom-engineered equipment or modifications of our standard designs.

Revere's high-volume production capacity and large inventory account for the great selection of equipment available for immediate delivery. Special facilities account for fast service on custom equipment available in production quantities for volume users. And Revere's policy of designing *up* to a performance level, never down to a price level gives users all the light they pay for in fixtures that outlast even their own expectations.

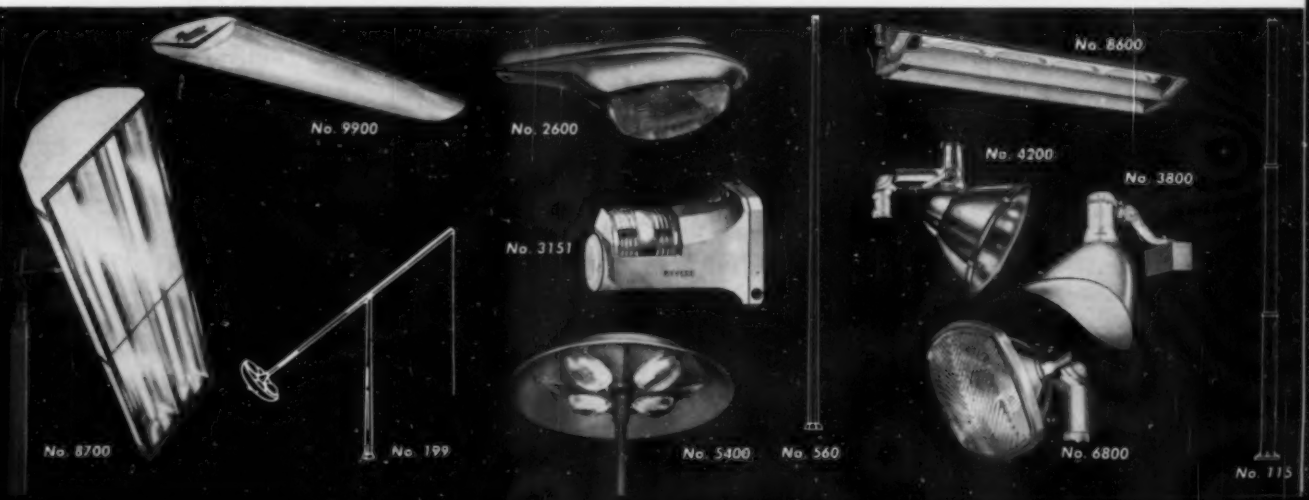
Revere offers consulting engineers and their clients the industry's widest line of outdoor fluorescent, incandescent and mercury luminaires as well as poles and accessories — *design* matched for best appearance and peak lighting efficiency, and *structurally* matched for strength, balance and trouble-free installation. For complete descriptive and technical data, write for your copy of Revere's comprehensive outdoor lighting catalog. For information on custom engineered lighting equipment, feel free to consult your Revere sales engineer. He can show why Revere is the consultant's choice.

Revere ELECTRIC MFG. CO.

OUTDOOR LIGHTING

Revere Electric Mfg. Co. • 7420 Lehigh Avenue • Chicago 48, Illinois (In suburban Niles)
Long Distance Phone: NI les 7-6060 • Chicago Phone: SPring 4-1200 • Telegrams: WUX Niles
In Canada: Curtis-Albright Lighting Ltd., Leaside, Toronto 17, Ontario RVR-O-213

Selecting everything you need in outdoor lighting from one reliable source saves time, trouble and money. Shown are just a few representative fluorescent, incandescent and mercury fixtures and poles from Revere's wide line.



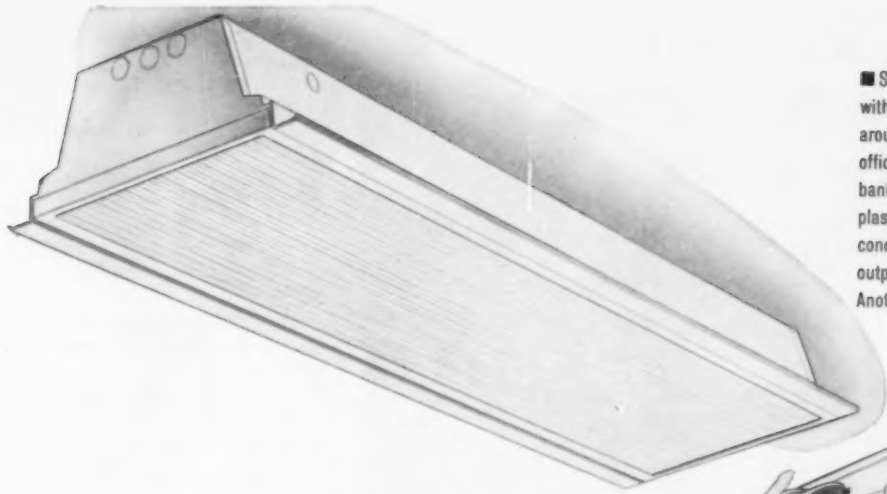
The wraps are off!

Curtis-AllBrite presents 3 new innovations in illumination . . . a series of advanced designs inaugurating a 10-year plan of product development!

Tomorrow is here! Curtis-AllBrite promised you the future and here it is in 3 new luminaries . . . truly inspired designs—advanced concepts in lighting. 1. Shallow Troffer "Slimplicity" unit with new Curtis-AllBrite CALux lens. Ideal for building concepts where ceiling installation areas are cut to a minimum. 2. The 88 Industrial Series . . . the first fixtures truly designed for Power-Groove lamps. Secret of superior performance is lamp spacing, assuring maximum lighting, longer lamp life, greater ballast efficiency. 3. The Curtis-AllBrite Ventro-Lux with Anemostat air diffuser, a complete package, providing illumination and air distribution (lighting, heating, cooling and ventilating) . . . a combination providing 4 utilities to cut installation costs 4 ways . . . available with the new CALux lens.

These new fixtures are the initial offering of the many new things you can expect from Curtis-AllBrite—a company that has over 50 firsts in the science of illumination. So look to Curtis-AllBrite for new ideas—new answers in lighting today, tomorrow, and 10 years from now. Curtis-AllBrite Lighting, Inc., 6135 W. 65th Street, Chicago 38, Illinois—352 Shaw Road, South San Francisco, California—Toronto, Canada—Vancouver, B.C., Canada.

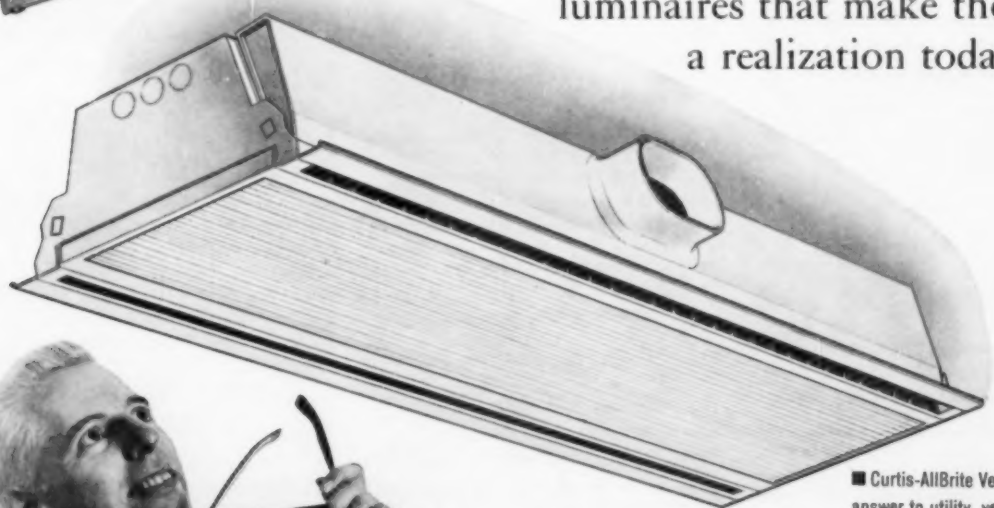
CURTIS-ALLBRITE
LIGHTING, INC.
Visioneers in Planned Lighting



■ Shallow Troffer "Slimplicity" unit—with flowing contours that will be around for years to come—ideal for offices, hospitals, schools, stores, and banks. Available with the new CALux plastic lens . . . providing maximum concealment of lamp . . . high output and attractive appearance. Another first from Curtis-AllBrite.

■ The new ALZAK 88 Industrial Series—bringing a new dimension to industrial lighting—a forward concept in harmony with today's plant designs.

Tomorrow is here! Look...look...look what's new for you...3 of a series of new luminaires that make the future a realization today!



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Installations in the News . . .

Relighting Modernizes Library—Economically

Modernization of the library at Tufts College, Medford, Mass., with no structural or decorative changes was achieved by a combination of perimeter wall washing lighting units and well-placed table lamps. Wood-shielded fluorescent units mounted above the bookcases around the perimeter of the room, wash the upper walls with light, supply illumination on the bookshelves, raise the general brightness level of the room, thus reducing contrast between the work area and the surroundings. Continuous line of table lamps with curved wood shields at eye-level provides even distribution of light over the work plane.

Photo and data courtesy of LAM, Inc., Wakefield, Mass.

(*Continued from page* 22A)

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(*Continued on page* 30A)

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Your decision to specify or install CIRCLGRID Light Controlling Louvers may require proof in use. With *over one million square feet* of CIRCLGRID installed may we direct you to a nearby user? A few are listed — there are many more.

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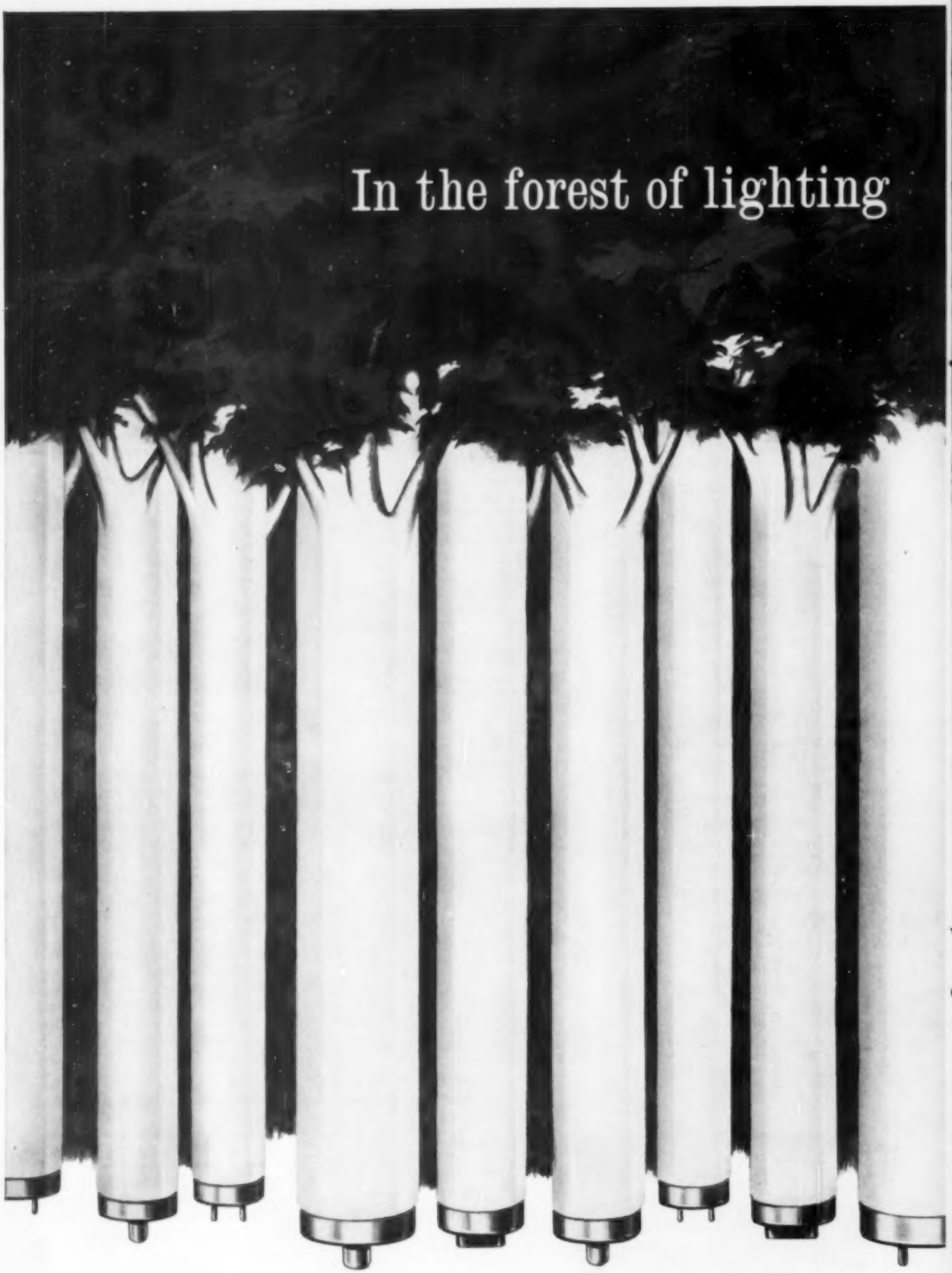
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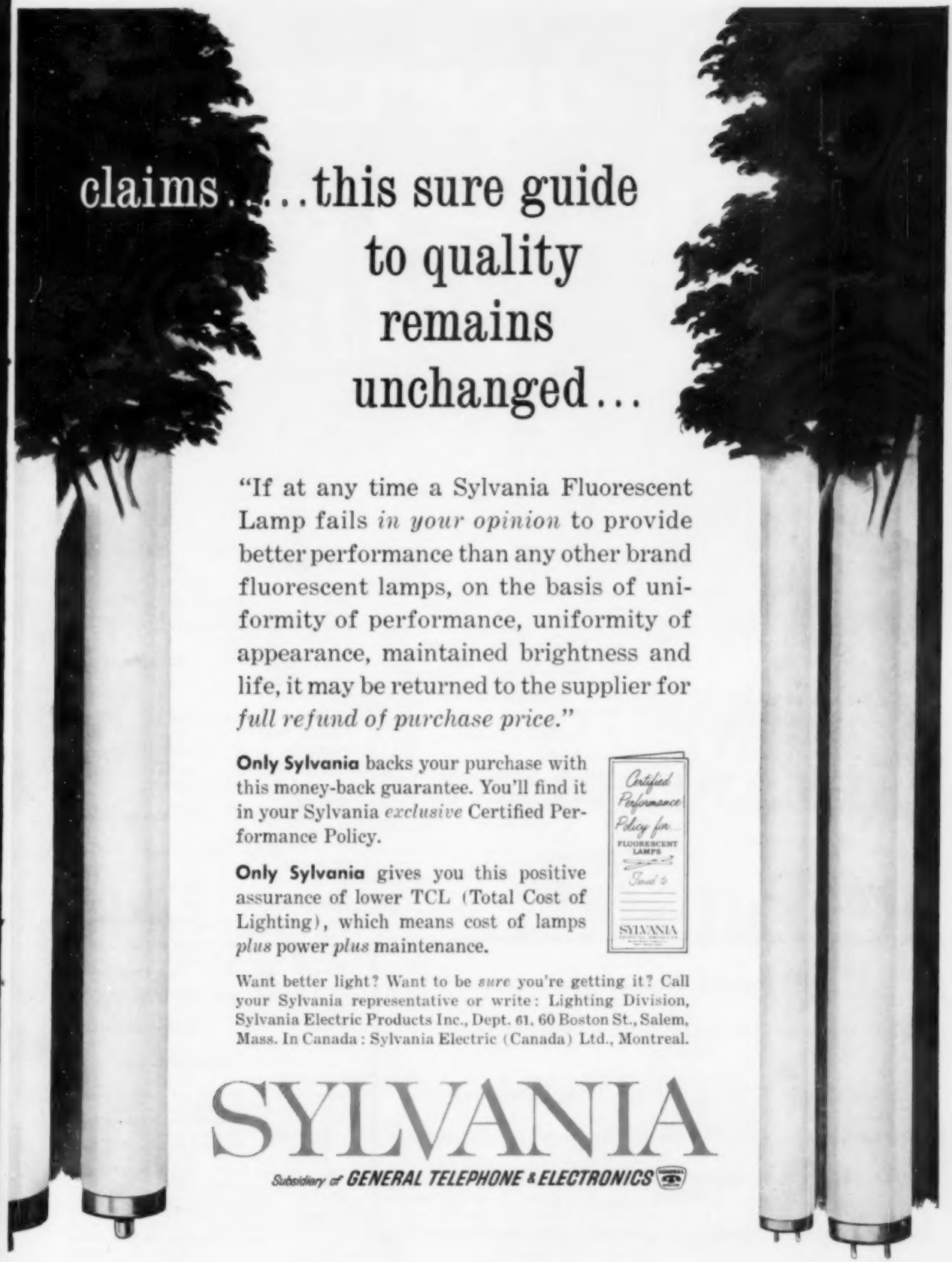

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YOSEMITE CHAPTER

No Elections

(*Continued on page 42A*)

IES National Technical Conferences

1961—September 24-29—Chase Park Plaza Hotel, St. Louis, Missouri

1962—September 9-14—Statler-Hilton Hotel, Dallas, Texas

1963—September 8-13—Sheraton-Cadillac Hotel, Detroit, Michigan

1964—August 30-September 3—Fontainebleau Hotel, Miami Beach, Florida

"America's finest fluorescent lighting"

Recessed Slendex solves tough ceiling problems . . . in low ceilings . . . in minimum cavities. Recessed only 1⅜" . . . so shallow it handles like tile. Surface-mounted Slendex is only 3" deep overall . . . ideal for low ceiling installations. Simplify your next project with Smithcraft Slendex. One foot wide for two lamps; two feet wide for four lamps.

Slendex, as well as all Smithcraft fluorescent lighting equipment, may be leased under the Smithcraft LEASE-LIGHT* Plan to conserve capital while enjoying the benefits of good lighting.

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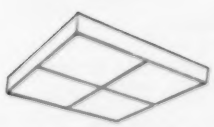

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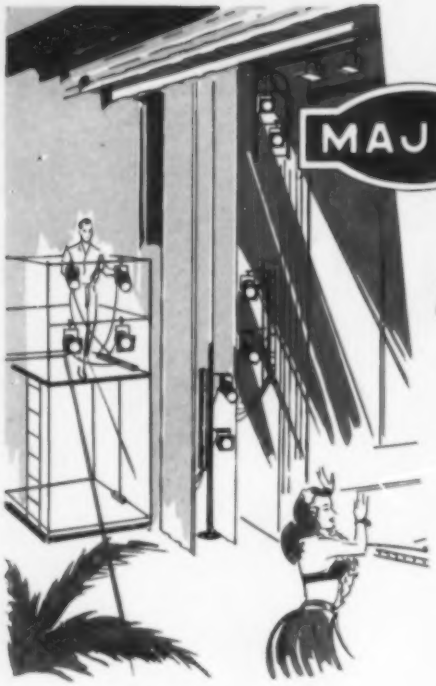

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Fabricated of special reflector grade aluminum, and Alzak processed for inherent resistance to corrosion and harmful atmospheric conditions. Will not rust, chip, tarnish or peel. Provide lasting brilliant reflection. Be sure to specify Major-Alzak reflectors for your lighting in each of these areas.

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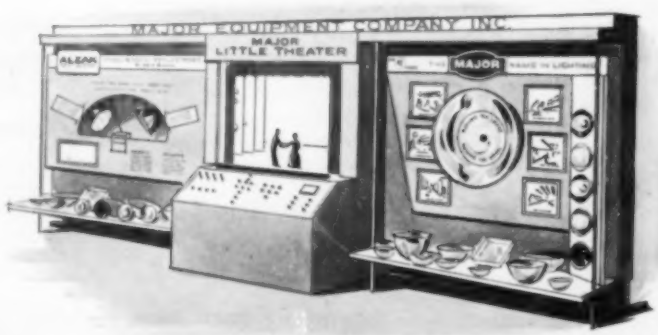

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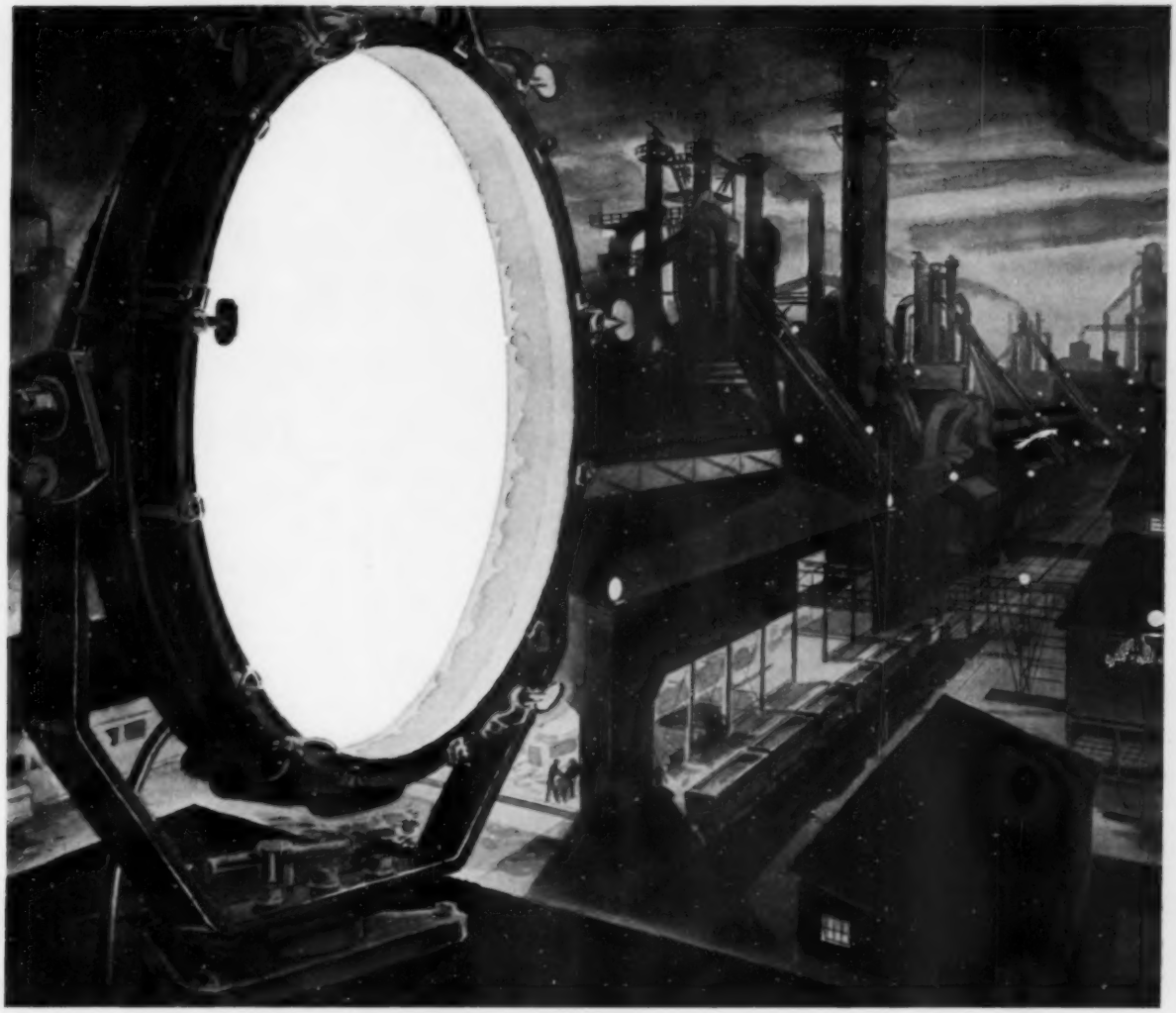

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Types and sizes are numerous; 200W-2000W incandescents in 12″ to 24″ lens diameters; 250W-1000W mercury vapors in 12″ to 20″ diameters. Order from five different beam spreads to light any shape or size area.

For complete specifications, see our Catalog #320 or Bulletin #2714 . . . or ask your Crouse-Hinds Distributor.

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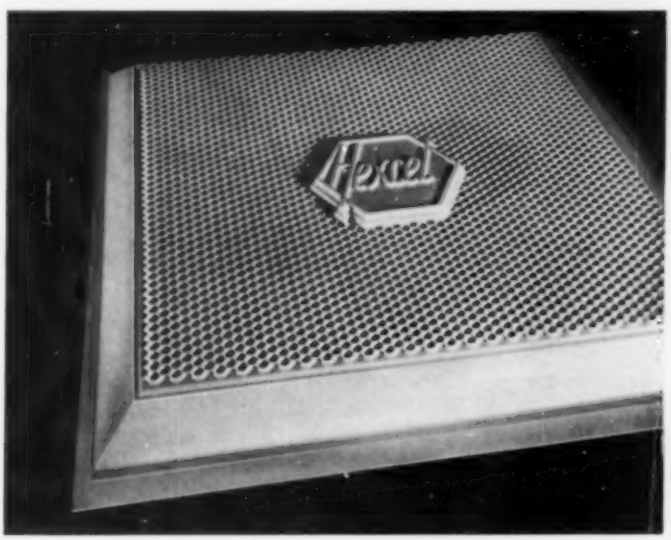
NEW design individuality can be added to Honeyglo panels by custom molding company name, trademark, or medallion into the honeycomb surface of the panels. Without sacrificing illumination levels, this unique decorative accent complements other interior design features of clubs, restaurants, hotels, or institutions.

HONEYGLO luminous ceilings are a product of Hexcel Products Inc., manufacturers of HONEYLITE® open-cell honeycomb louvers. For complete information on the Hexcel product best suited to your lighting requirements, call your nearest Hexcel representative. Or write Dept. 1-K.



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Robert Hyde Wilson, Supervising Director
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PLAYBOX THEATRE-IN-THE ROUND
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ARIELITES used in the production of student players presentation of Jean Anouihl's "Antigone" U. of U. Playbox, Benjamin F. Carney, Director

"ARIELITES give us maximum lighting flexibility and efficiency at minimum cost. We have found these instruments to be ideal for such varied productions as a reading theatre presentation of O'Casey's 'Pictures in the Hallway' and the central staging of Anouihl's 'Antigone.' The wide range of parabolic reflector lamps available, from wide floods to pin spots, allows beam spreads and angles to suit all our needs.

"The instrument which helped solve some of our most difficult area lighting problems was the new ARIELITE Framers, using PAR 64 lamps, which cost us less than $40.00 per unit!

"ARIELITES have been our answer to the problem of achieving artistic lighting at low cost."

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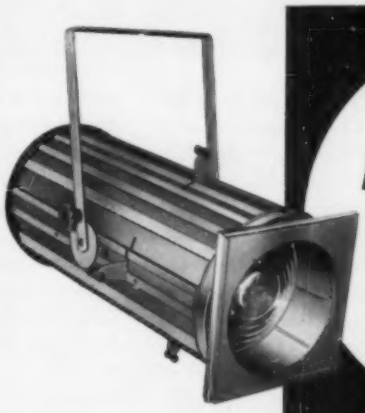

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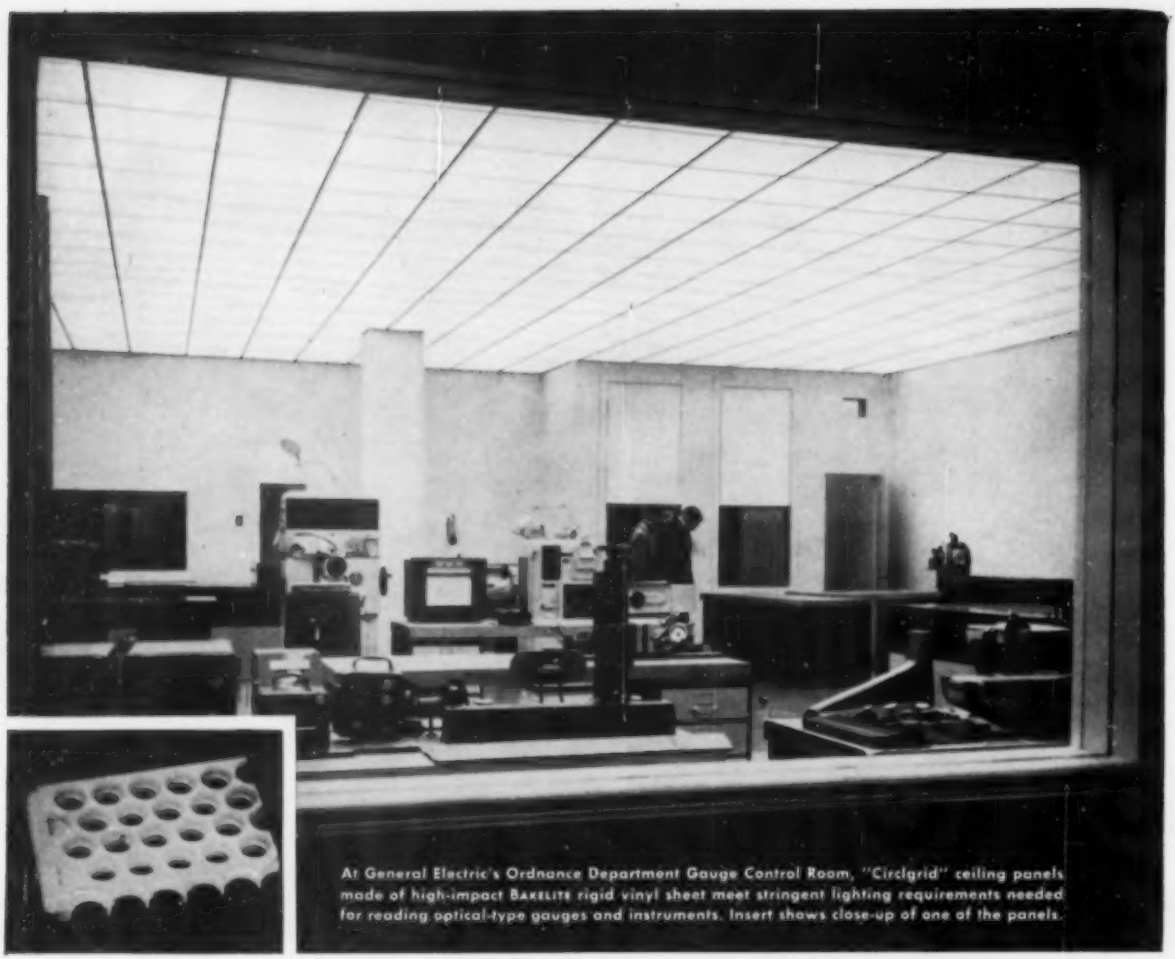

At General Electric's Ordnance Department Gauge Control Room, "Circlgrid" ceiling panels made of high-impact BAKELITE rigid vinyl sheet meet stringent lighting requirements needed for reading optical-type gauges and instruments. Insert shows close-up of one of the panels.

Controlled Light for Control Room

LUMINOUS CEILING GIVES UNIFORM DIFFUSION, HIGH LIGHT TRANSMISSION, FOR INSTRUMENT READING

Shadow-free lighting! That's one of the critical requirements for this gauge control room of General Electric's Ordnance Department plant in Pittsfield, Mass. At the same time, uniform light diffusion and high lighting efficiency are essential.

To meet the requirements, "Circlgrid" panels were designed by Cirvac Plastics of Erie, Pa.—employing new *high-impact* BAKELITE rigid vinyl sheet. Each panel is made from two vacuum-formed sheets bonded together. The many small circular depressions in the panels are punched out. The over-all result is intrinsic light control, with brightness reduced in the glare zone between 45° and 90°. This permits higher foot-candle installation.

The holes also reduce dust accumulation, simplify cleaning, and allow free air circulation. Transmission efficiency is 68 per cent, compared to the 48 per cent of most standard vinyl diffusers. Illumination in this installation is at the 150 foot-candle level, with a brightness ratio never exceeding 5 to 1.

Highly resistant to warping, cracking, the panels go years without discoloration from ultraviolet. They are self-extinguishing, and the holes allow sprinklers above to operate efficiently—the National Board of Fire Underwriters has approved vinyl diffusers in this regard with perforations of ¼ inch or larger. "Circlgrid" panels have been approved by the building code of nearly every major city, including the strict New York code.

Look into ceilings made with high-impact BAKELITE rigid vinyl sheet. Write for more information. Dept. JO-72B, Union Carbide Plastics Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y.

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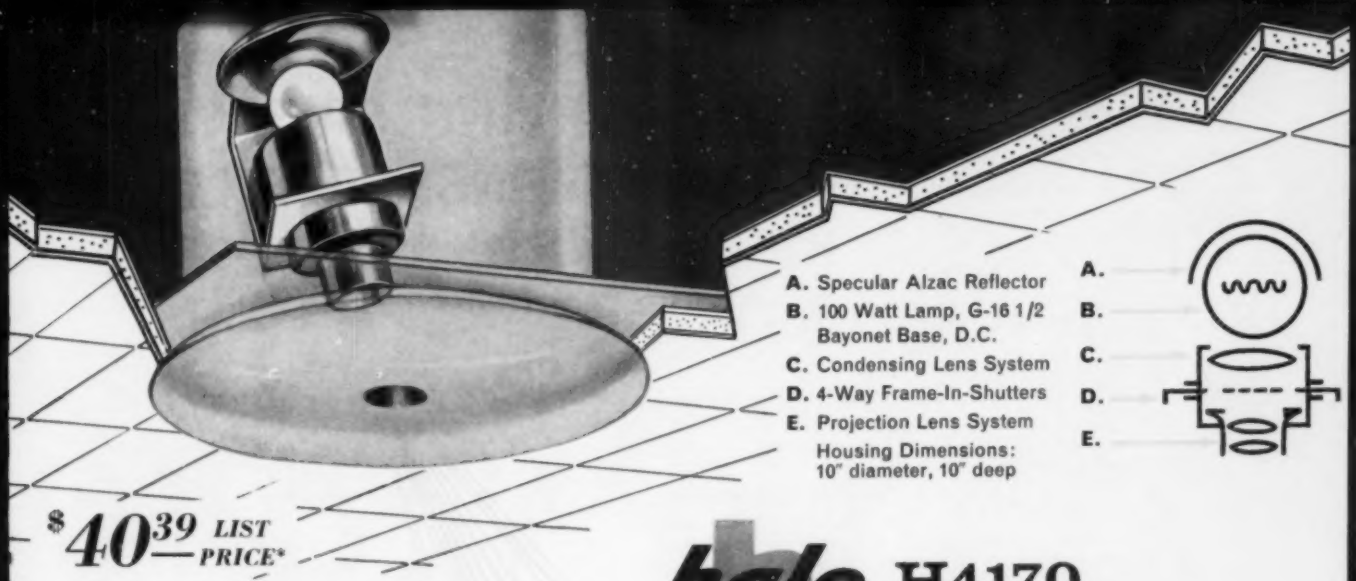

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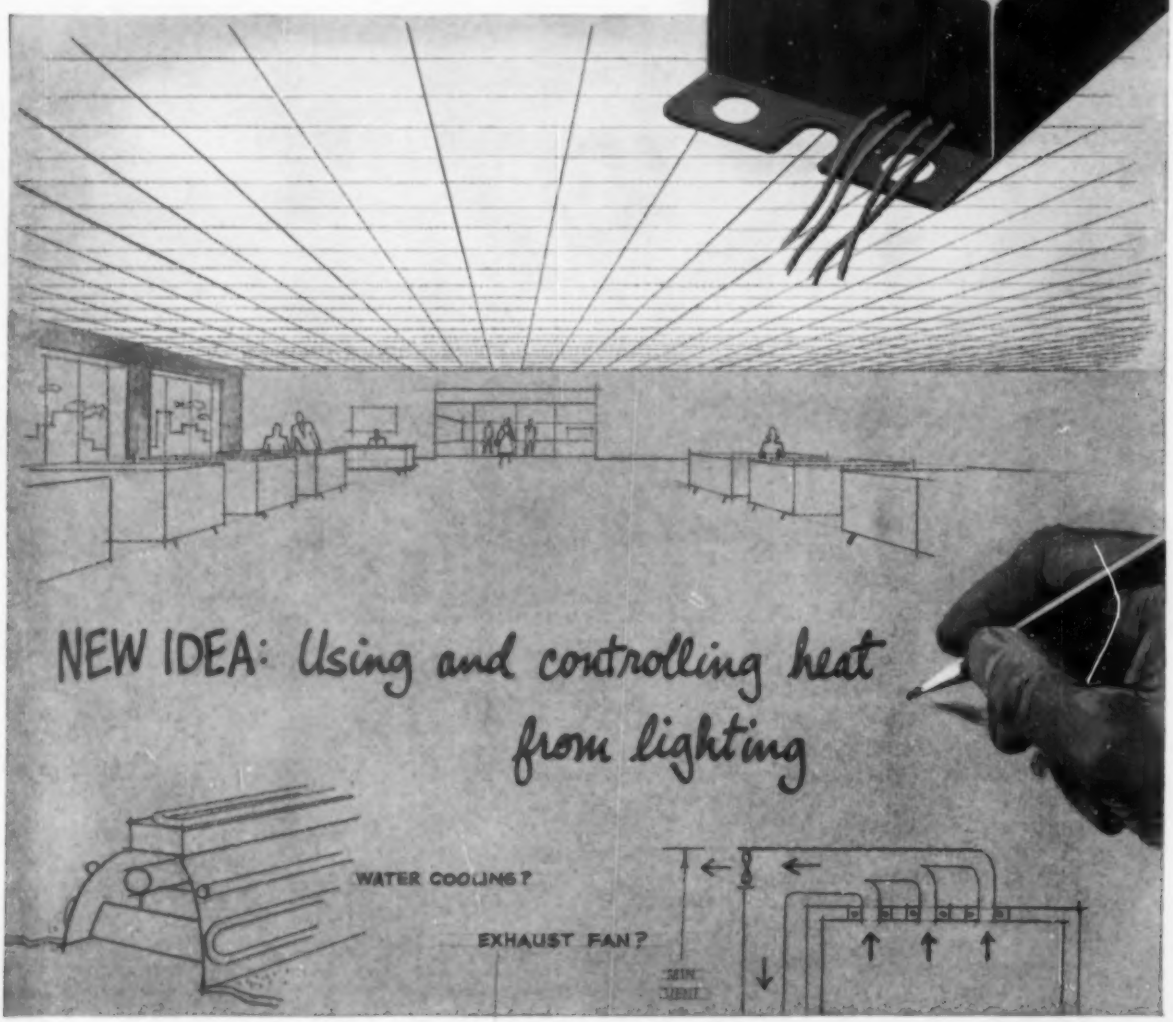
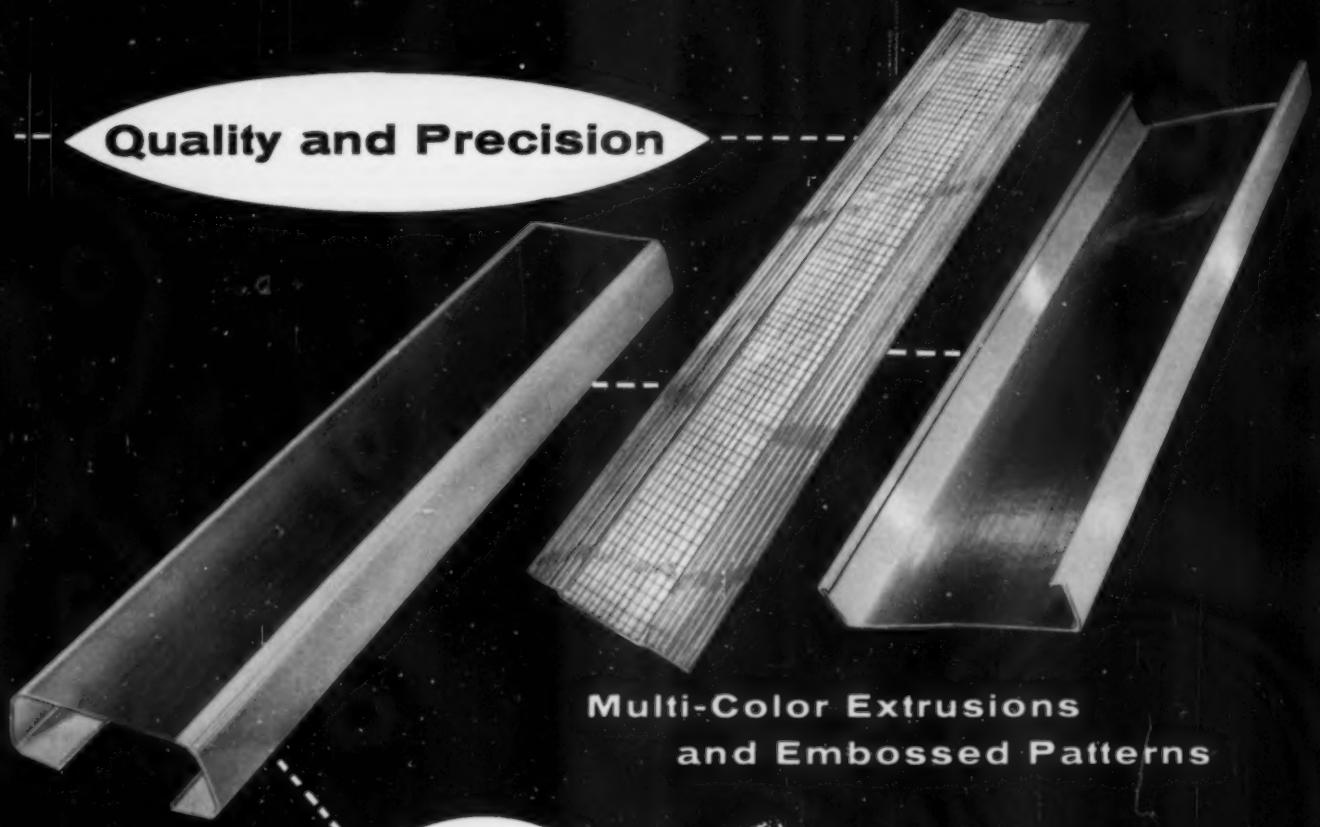


Quality and Precision



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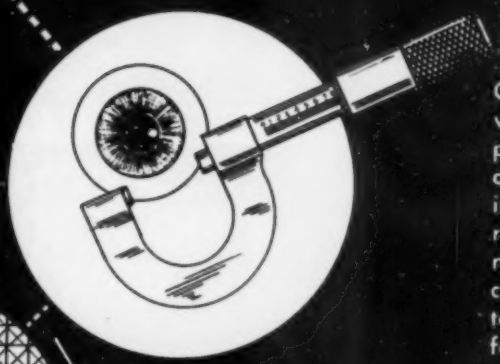

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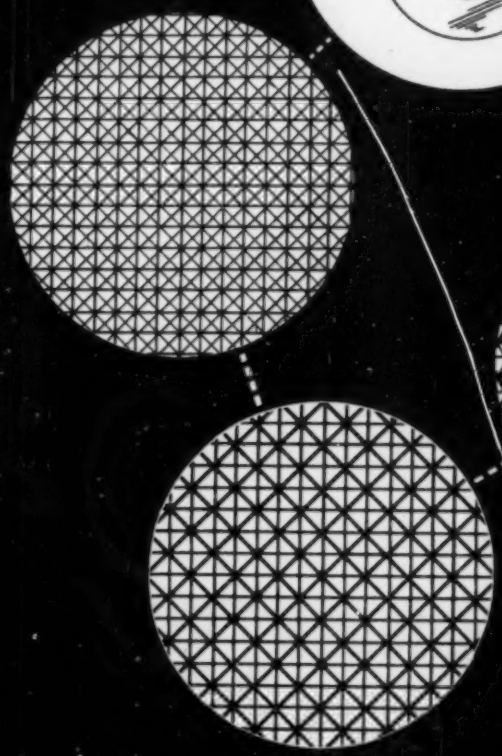

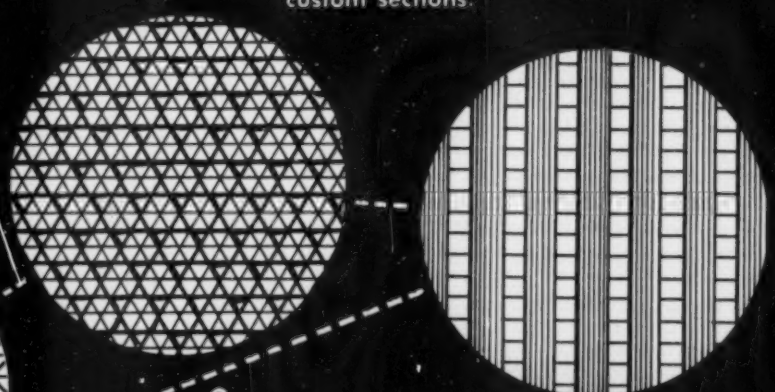

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Westinghouse Lamp Division, Westinghouse Electric Corporation, Bloomfield, New Jersey

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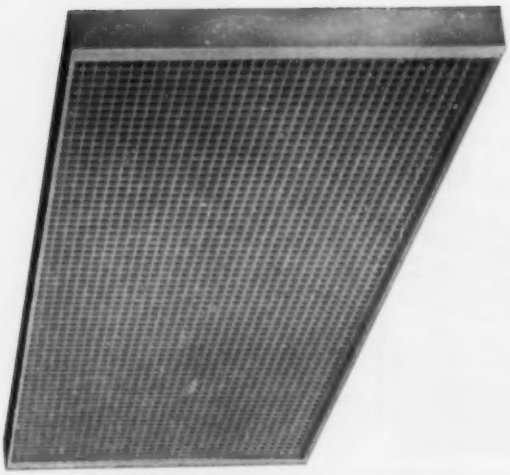

QPCX7400 "Wrap-around" all-plastic enclosure.

QRH7500 (Sculpturama®) with all-curved styling.

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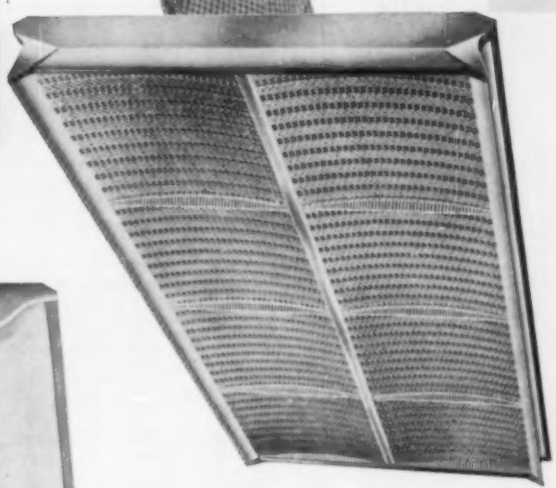

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The difference between night and day

Continued from page 30A)

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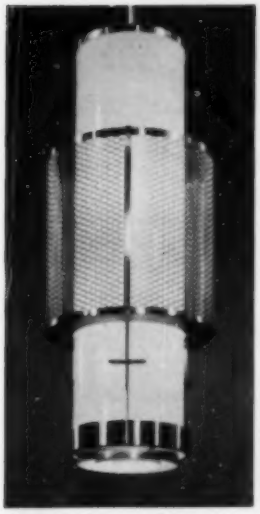

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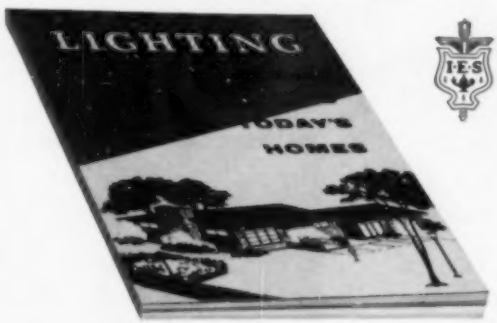

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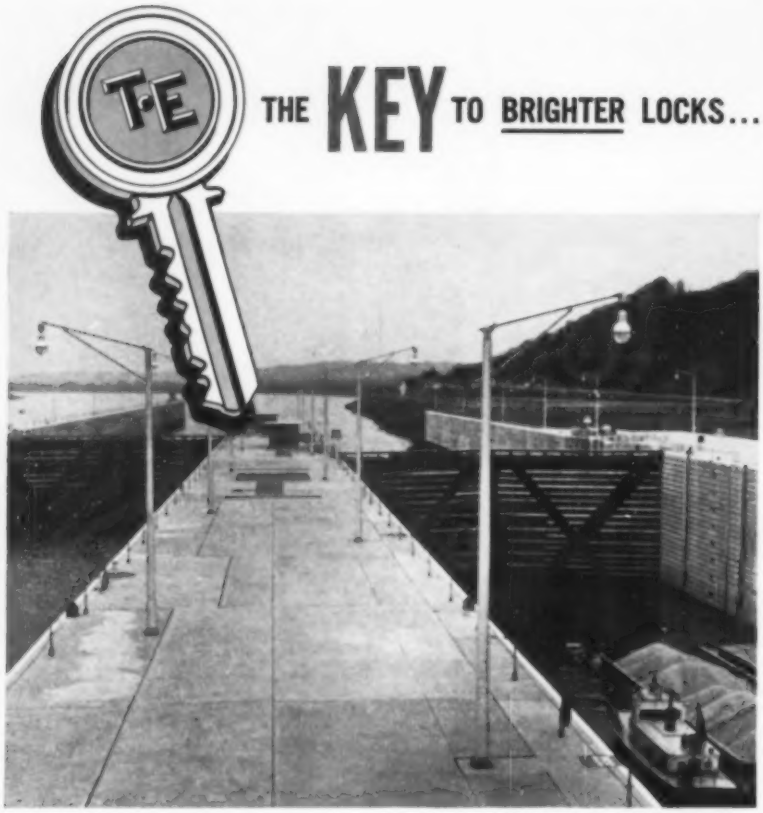

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LIGHTING

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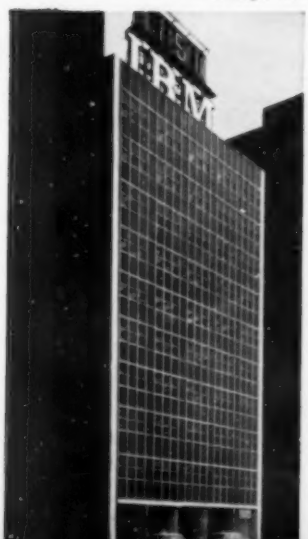

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